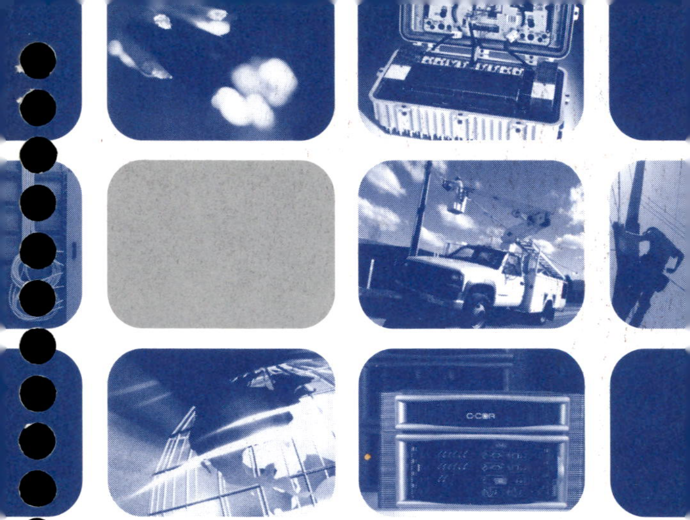

Broadband Pocket Guide

C-COR

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Broadband Pocket Guide

Document MX0398

Revision G

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Introduction

This Pocket Guide is divided into ten chapters. The right pages of each chapter are marked with a tab that lines up with the thumb index tabs on the right side of this page. You can quickly find the first page of each chapter by flipping through the pages of this Pocket Guide to find the chapter that you want or by using the Table of Contents which follows.

Disclaimer

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Product Data 1

RF Data 2

RF Calculations 3

Maintenance and Troubleshooting 4

International TV Formats 5

Cable, Taps, and Passives 6

Fiber Data 7

Symbols and Acronyms 8

Data Transmission 9

Miscellaneous Data 10

Table of Contents

1 Product Data

Plug-in Accessories 1-2
Transfer Linearization Technology 1-4

2 RF Data

Television Channel Frequency Data 2-2
HRC Channel Plan. 2-7
UHF Channel Plan. 2-11
FCC Rules and Regulations, Part 76 2-13
Performance Standards 2-19
Frequency Allocation Chart 2-20

3 RF Calculations

Determining Carrier Levels 3-2
System Performance Equations 3-7
Output Level on Performance 3-14
CSO and CTB 3-16
Derating Performance 3-31
Voltage Addition Chart. 3-34
Power Addition Chart 3-35
Spectrum Analyzer Error Correction Chart 3-36
dBmV/Hz Bandwidth Conversion 3-37
Return Loss, Reflection, and Standing Waves 3-38

4 Maintenance and Troubleshooting

Cumulative Leakage Index Calculation (CLI) 4-2
Maximum Leakage Field Strength Levels 4-3
Leakage Measurement at Different Distances. 4-4
Dipole Antenna Equations 4-5
Sweep vs. Balance 4-6
Troubleshooting. 4-11

5 International TV Formats

International Channel Standards 5-2
Channel Formats 5-5
Distortion Conversions for International TV 5-7
Carrier Options 5-8

6 Cable, Taps, and Passives

Basic Cable Calculations 6-2
Cable Specifications. 6-6
RF Taps and Passives 6-14

7 Fiber Data

Fiber Optic Color Code . . . 7-2
Fiber Loss . . . 7-2
Optical Connectors . . . 7-3
Optical Attenuators . . . 7-5
Optical Couplers and Splitters . . . 7-5
Wavelength Division Multiplexing (WDM) . . . 7-7
Dense Wavelength Division Multiplexing (DWDM) . . . 7-8
Optical Modulation Index (OMI) . . . 7-15
dBm Conversions . . . 7-18

8 Symbols and Acronyms

Common CATV Symbols . . . 8-2
Common Industry Acronyms . . . 8-3

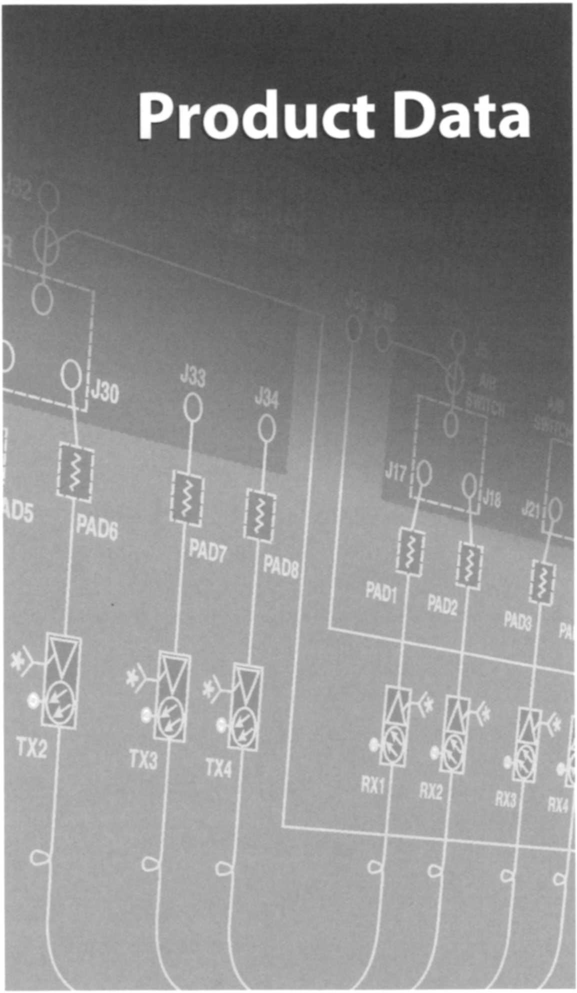
9 Data Transmission

Digitizing an Analog Signal . . . 9-2
QAM Transmission Basics . . . 9-4
QAM Constellation Diagram Analysis . . . 9-6
BER, FEC, MER . . . 9-10
Common Industry Data Rates . . . 9-14

10 Miscellaneous Data

Scientific Prefix Symbols and Values . . . 10-2
Unit Abbreviations . . . 10-2
Unit Conversion Factors . . . 10-3
Ohm's Law / Joule's Law Pie Chart . . . 10-4
75 Ohm T and Pi Attenuators . . . 10-5
Directional Couplers . . . 10-7
dBmV to mV Conversion (for 75Ω systems) . . . 10-8
Celsius/Fahrenheit Conversion . . . 10-9
Data Interface Connectors . . . 10-10

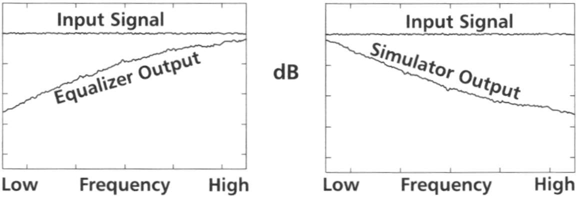
Product Data


J32
J30
J33
J34
PAD5
PAD6
PAD7
PAD8
TX2
TX3
TX4
J5
A/B SWITCH
A/B SWITCH
J17
J18
J21
PAD1
PAD2
PAD3
RX1
RX2
RX3
RX4

1.1 Plug-in Accessories

Plug-in accessories are used to adjust the level and "tilt" of an RF signal to produce a desired result. (Tilt is the signal level difference between the highest and lowest system frequency carriers. Generally, the higher frequencies have more loss than the lower frequencies.) Tilt can be changed in either direction, positive or negative. Positive tilt is desired and occurs when the high frequencies have more signal level than the low frequencies.

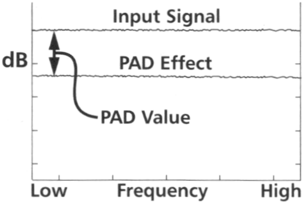
Cable Equalizers compensate for the tilt produced by coaxial cable. That is, equalizers counteract the cable-induced loss in the signal by attenuating low frequency carriers more than high frequency carriers. See figure below, left.



Equalizer and Simulator Effects on Signal

Cable Simulators perform the opposite function of equalizers. That is, simulators attenuate high frequency carriers more than low frequency carriers, as does cable. They are typically used when a length of cable has less than the required input "tilt" loss for a particular amplifier. See figure above, right.

Attenuators (PADs) attenuate (decrease) signal without regard to frequency, reducing level equally within the band for which they are rated. See figure at right.



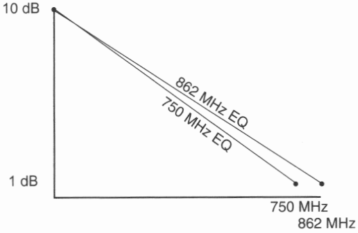
PAD Effects on Signal

Accessories may be used in systems with frequency the same as or *lower* than the accessory rating, but *not* in systems using frequencies *higher* than the accessory rating.

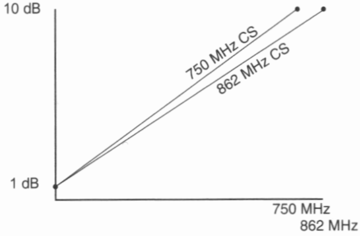
This means that 862 MHz accessories may be used in 750 MHz system or lower frequency systems. *However,* the attenuation value of an 862 MHz EQ is greater than that of the 750 MHz EQ at 750 MHz and the attenuation difference narrows as the frequency approaches 0 MHz. Conversely, the attenuation value of an 862 MHz CS is less than that of the 750 MHz CS at 750 MHz and the attenuation difference narrows as the frequency approaches 0 MHz.

> ***Note****: A 750 MHz accessory should not be used in an 862 MHz system.*

EQ



CS



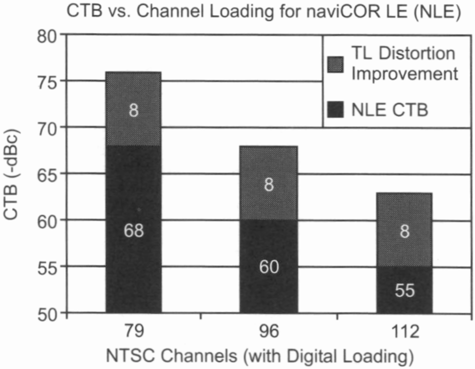
1.2 Transfer Linearization Technology

TL Technology improves the linear characteristics of standard, highly reliable silicon technology hybrids, thereby allowing for higher operating level capabilities and/or improved distortion performance, in addition to higher channel capacities and improved system level performance.

The higher operating levels that can be achieved with TL enhanced products can also translate into fewer active devices necessary in the HFC architecture, thus reducing maintenance, installation, and powering costs.

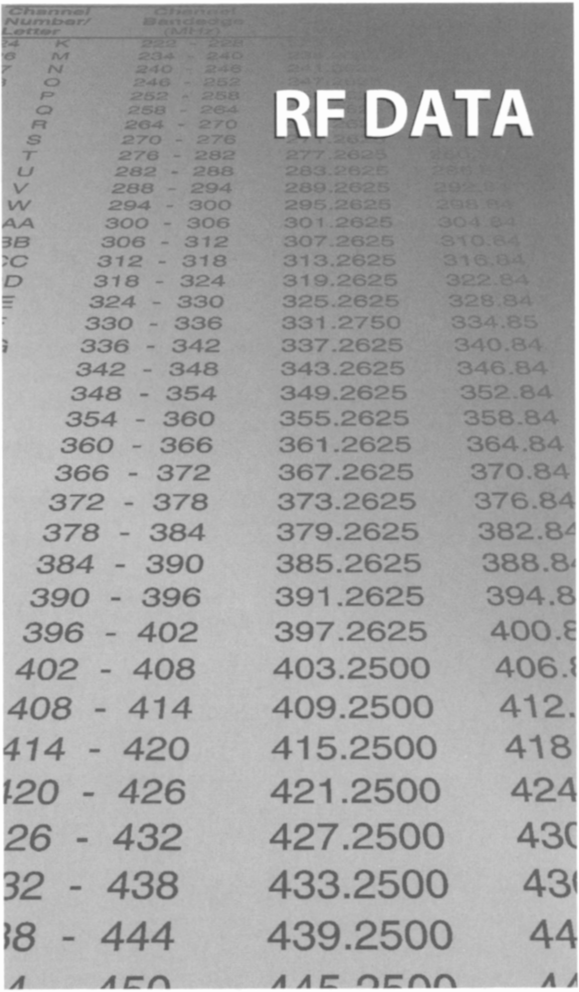
Utilizing TL Technology with standard silicon-based hybrid technology offers the distinct advantage of leveraging silicon's long-term, proven reliability with comparable performance to GaAs (Gallium Arsenide) technology.

Composite Triple Beat improvements on the order of 8 dB can be realized with TL Technology. Performance improvement of our fiber optic nodes and RF launch amplifiers will allow system operators to maintain high-output HFC systems with increased performance.



Levels
79 NTSC—46/37 @ 550/54 MHz w/ 300 MHz digital noise
96 NTSC—48/37 @ 650/54 MHz w/ 200 MHz digital noise
112 NTSC—49.5/37 @ 750/54 MHz w/ 100 MHz digital noise

RF DATA



2.1 Television Channel Frequency Data

Channels T-7 through T-13 are return channels.

FCC Frequency Allocation

Channel Number/ Letter		Channel Bandedge (MHz)	Visual Carrier (MHz)	Chroma Carrier (MHz)	Aural Carrier (MHz)
T-7		5.75 – 11.75	7.0000	10.58	11.5000
T-8		11.75 – 17.75	13.0000	16.58	17.5000
T-9		17.75 – 23.75	19.0000	22.58	23.5000
T-10		23.75 – 29.75	25.0000	28.58	29.5000
T-11		29.75 – 35.75	31.0000	34.58	35.5000
T-12		35.75 – 41.75	37.0000	40.58	41.5000
T-13		41.75 – 47.75	43.0000	46.58	47.5000
2		54 – 60	55.2500	58.83	59.7500
3		60 – 66	61.2500	64.83	65.7500
4		66 – 72	67.2500	70.83	71.7500
	A-8	72 – 76		Guardband	
5		76 – 82	77.2500	80.83	81.7500
6		82 – 88	83.2500	86.83	87.7500
				Guardband	
95	A-5	90 – 96	91.2500	94.83	95.7500
96	A-4	96 – 102	97.2500	100.83	101.7500
97	A-3	102 – 108	103.2500	106.83	107.7500
98	A-2	108 – 114	109.2750	112.855	113.7750
99	A-1	114 – 120	115.2750	118.855	119.7750
14	A	120 – 126	121.2625	124.84	125.7625
15	B	126 – 132	127.2625	130.84	131.7625
16	C	132 – 138	133.2625	136.84	137.7625
17	D	138 – 144	139.2500	142.83	143.7500
18	E	144 – 150	145.2500	148.83	149.7500
19	F	150 – 156	151.2500	154.83	155.7500
20	G	156 – 162	157.2500	160.83	161.7500
21	H	162 – 168	163.2500	166.83	167.7500
22	I	168 – 174	169.2500	172.83	173.7500
7		174 – 180	175.2500	178.83	179.7500
8		180 – 186	181.2500	184.83	185.7500
9		186 – 192	187.2500	190.83	191.7500
10		192 – 198	193.2500	196.83	197.7500
11		198 – 204	199.2500	202.83	203.7500
12		204 – 210	205.2500	208.83	209.7500
13		210 – 216	211.2500	214.83	215.7500

FCC Frequency Allocation (cont'd)

Channel Number/ Letter		Channel Bandedge (MHz)	Visual Carrier (MHz)	Chroma Carrier (MHz)	Aural Carrier (MHz)
23	J	216 – 222	217.2500	220.83	221.7500
24	K	222 – 228	223.2500	226.83	227.7500
25	L	228 – 234	229.2625	232.84	233.7625
26	M	234 – 240	235.2625	238.84	239.7625
27	N	240 – 246	241.2625	244.84	245.7625
28	O	246 – 252	247.2625	250.84	251.7625
29	P	252 – 258	253.2625	256.84	257.7625
30	Q	258 – 264	259.2625	262.84	263.7625
31	R	264 – 270	265.2625	268.84	269.7625
32	S	270 – 276	271.2625	274.84	275.7625
33	T	276 – 282	277.2625	280.84	281.7625
34	U	282 – 288	283.2625	286.84	287.7625
35	V	288 – 294	289.2625	292.84	293.7625
36	W	294 – 300	295.2625	298.84	299.7625
37	AA	300 – 306	301.2625	304.84	305.7625
38	BB	306 – 312	307.2625	310.84	311.7625
39	CC	312 – 318	313.2625	316.84	317.7625
40	DD	318 – 324	319.2625	322.84	323.7625
41	EE	324 – 330	325.2625	328.84	329.7625
42	FF	330 – 336	331.2750	334.85	335.7750
43	GG	336 – 342	337.2625	340.84	341.7625
44	HH	342 – 348	343.2625	346.84	347.7625
45	II	348 – 354	349.2625	352.84	353.7625
46	JJ	354 – 360	355.2625	358.84	359.7625
47	KK	360 – 366	361.2625	364.84	365.7625
48	LL	366 – 372	367.2625	370.84	371.7625
49	MM	372 – 378	373.2625	376.84	377.7625
50	NN	378 – 384	379.2625	382.84	383.7625
51	OO	384 – 390	385.2625	388.84	389.7625
52	PP	390 – 396	391.2625	394.84	395.7625
53	QQ	396 – 402	397.2625	400.84	401.7625
54	RR	402 – 408	403.2500	406.83	407.7500
55	SS	408 – 414	409.2500	412.83	413.7500
56	TT	414 – 420	415.2500	418.83	419.7500
57	UU	420 – 426	421.2500	424.83	425.7500
58	VV	426 – 432	427.2500	430.83	431.7500
59	WW	432 – 438	433.2500	436.83	437.7500
60	XX	438 – 444	439.2500	442.83	443.7500

FCC Frequency Allocation (cont'd)

Channel Number/ Letter		Channel Bandedge (MHz)	Visual Carrier (MHz)	Chroma Carrier (MHz)	Aural Carrier (MHz)
61	YY	444 – 450	445.2500	448.83	449.7500
62	ZZ	450 – 456	451.2500	454.83	455.7500
63	AAA	456 – 462	457.2500	460.83	461.7500
64	BBB	462 – 468	463.2500	466.83	467.7500
65	CCC	468 – 474	469.2500	472.83	473.7500
66	DDD	474 – 480	475.2500	478.83	479.7500
67	EEE	480 – 486	481.2500	484.83	485.7500
68	FFF	486 – 492	487.2500	490.83	491.7500
69	GGG	492 – 498	493.2500	496.83	497.7500
70	HHH	498 – 504	499.2500	502.83	503.7500
71	III	504 – 510	505.2500	508.83	509.7500
72	JJJ	510 – 516	511.2500	514.83	515.7500
73	KKK	516 – 522	517.2500	520.83	521.7500
74	LLL	522 – 528	523.2500	526.83	527.7500
75	MMM	528 – 534	529.2500	532.83	533.7500
76	NNN	534 – 540	535.2500	538.83	539.7500
77	OOO	540 – 546	541.2500	544.83	545.7500
78	PPP	546 – 552	547.2500	550.83	551.7500
79	QQQ	552 – 558	553.2500	556.83	557.7500
80	RRR	558 – 564	559.2500	562.83	563.7500
81	SSS	564 – 570	565.2500	568.83	569.7500
82	TTT	570 – 576	571.2500	574.83	575.7500
83	UUU	576 – 582	577.2500	580.83	581.7500
84	VVV	582 – 588	583.2500	586.83	587.7500
85	WWW	588 – 594	589.2500	592.83	593.7500
86	XXX	594 – 600	595.2500	598.83	599.7500
87	YYY	600 – 606	601.2500	604.83	605.7500
88	ZZZ	606 – 612	607.2500	610.83	611.7500
89		612 – 618	613.2500	616.83	617.7500
90		618 – 624	619.2500	622.83	623.7500
91		624 – 630	625.2500	628.83	629.7500
92		630 – 636	631.2500	634.83	635.7500
93		636 – 642	637.2500	640.83	641.7500
94		642 – 648	643.2500	646.83	647.7500
100		648 – 654	649.2500	652.83	653.7500
101		654 – 660	655.2500	658.83	659.7500
102		660 – 666	661.2500	664.83	665.7500
103		666 – 672	667.2500	670.83	671.7500

FCC Frequency Allocation (cont'd)

Channel Number/ Letter	Channel Bandedge (MHz)	Visual Carrier (MHz)	Chroma Carrier (MHz)	Aural Carrier (MHz)
104	672 – 678	673.2500	676.83	677.7500
105	678 – 684	679.2500	682.83	683.7500
106	684 – 690	685.2500	688.83	689.7500
107	690 – 696	691.2500	694.83	695.7500
108	696 – 702	697.2500	700.83	701.7500
109	702 – 708	703.2500	706.83	707.7500
110	708 – 714	709.2500	712.83	713.7500
111	714 – 720	715.2500	718.83	719.7500
112	720 – 726	721.2500	724.83	725.7500
113	726 – 732	727.2500	730.83	731.7500
114	732 – 738	733.2500	736.83	737.7500
115	738 – 744	739.2500	742.83	743.7500
116	744 – 750	745.2500	748.83	749.7500
117	750 – 756	751.2500	754.83	755.7500
118	756 – 762	757.2500	760.83	761.7500
119	762 – 768	763.2500	766.83	767.7500
120	768 – 774	769.2500	772.83	773.7500
121	774 – 780	775.2500	778.83	779.7500
122	780 – 786	781.2500	784.83	785.7500
123	786 – 792	787.2500	790.83	791.7500
124	792 – 798	793.2500	796.83	797.7500
125	798 – 804	799.2500	802.83	803.7500
126	804 – 810	805.2500	808.83	809.7500
127	810 – 816	811.2500	814.83	815.7500
128	816 – 822	817.2500	820.83	821.7500
129	822 – 828	823.2500	826.83	827.7500
130	828 – 834	829.2500	832.83	833.7500
131	834 – 840	835.2500	838.83	839.7500
132	840 – 846	841.2500	844.83	845.7500
133	846 – 852	847.2500	850.83	851.7500
134	852 – 858	853.2500	856.83	857.7500
135	858 – 864	859.2500	862.83	863.7500
136	864 – 870	865.2500	868.83	869.7500
137	870 – 876	871.2500	874.83	875.7500
138	876 – 882	877.2500	880.83	881.7500
139	882 – 888	883.2500	886.83	887.7500
140	888 – 894	889.2500	892.83	893.7500
141	894 – 900	895.2500	898.83	899.7500

FCC Frequency Allocation (cont'd)

Channel Number/ Letter	Channel Bandedge (MHz)	Visual Carrier (MHz)	Chroma Carrier (MHz)	Aural Carrier (MHz)
142	900 – 906	901.2500	904.83	905.7500
143	906 – 912	907.2500	910.83	911.7500
144	912 – 918	913.2500	916.83	917.7500
145	918 – 924	919.2500	922.83	923.7500
146	924 – 930	925.2500	928.83	929.7500
147	930 – 936	931.2500	934.83	935.7500
148	936 – 942	937.2500	940.83	941.7500
149	942 – 948	943.2500	946.83	947.7500
150	948 – 954	949.2500	952.83	953.7500
151	954 – 960	955.2500	958.83	959.7500
152	960 – 966	961.2500	964.83	965.7500
153	966 – 972	967.2500	970.83	971.7500
154	972 – 978	973.2500	976.83	977.7500
155	978 – 984	979.2500	982.83	983.7500
156	984 – 990	985.2500	988.83	989.7500
157	990 – 996	991.2500	994.83	995.7500
158	996 – 1002	997.2500	1000.83	1001.7500

2.2 HRC Channel Plan

Channels T-7 through T-13 are return channels.

Harmonically Related Carriers

Channel Number/ Letter		Channel Bandedge (MHz)	Visual Carrier (MHz)	Chroma Carrier (MHz)	Aural Carrier (MHz)
T-7		–	–	–	–
T-8		–	–	–	–
T-9		–	–	–	–
T-10		–	–	–	–
T-11		–	–	–	–
T-12		–	–	–	–
T-13		–	–	–	–
2		52.75 – 58.75	54.00	57.58	58.50
3		58.75 – 64.75	60.00	63.58	64.50
4		64.75 – 70.75	66.00	69.58	70.50
	A-8	–		Guardband	
5		76.75 – 82.75	78.00	79.58	80.50
6		82.75 – 88.75	84.00	85.58	86.50
95	A-5	88.75 – 94.75	90.00	93.58	94.50
96	A-4	94.75 – 100.75	96.00	99.58	100.50
97	A-3	100.75 – 106.75	102.01	105.59	106.50
98	A-2	106.75 – 112.75	108.01	111.59	112.50
99	A-1	112.75 – 118.75	114.01	117.59	118.50
14	A	118.75 – 124.75	120.01	123.59	124.51
15	B	124.75 – 130.75	126.01	129.59	130.51
16	C	130.75 – 136.75	132.01	135.59	136.51
17	D	136.75 – 142.75	138.01	141.59	142.51
18	E	142.75 – 148.75	144.01	147.59	148.51
19	F	148.75 – 154.75	150.01	153.59	154.51
20	G	154.75 – 160.75	156.01	159.59	160.51
21	H	160.75 – 166.75	162.01	165.59	166.51
22	I	166.75 – 172.75	168.01	171.59	172.51
7		172.75 – 178.75	174.01	177.59	178.51
8		178.75 – 184.75	180.01	183.59	184.51
9		184.75 – 190.75	186.01	189.59	190.51
10		190.75 – 196.75	192.01	195.59	196.51
11		196.75 – 202.75	198.01	201.59	202.51
12		202.75 – 208.75	204.01	207.59	208.51
13		208.75 – 214.75	210.01	213.59	214.51
23	J	214.75 – 220.75	216.01	219.59	220.51

Harmonically Related Carriers (cont'd)

Channel Number/ Letter		Channel Bandedge (MHz)	Visual Carrier (MHz)	Chroma Carrier (MHz)	Aural Carrier (MHz)
24	K	220.75 – 226.75	222.01	225.59	226.51
25	L	226.75 – 232.75	228.01	231.59	232.51
26	M	232.75 – 238.75	234.01	237.59	238.51
27	N	238.75 – 244.75	240.01	243.59	244.51
28	O	244.75 – 250.75	246.01	249.59	250.51
29	P	250.75 – 256.75	252.01	255.59	256.51
30	Q	256.75 – 262.75	258.01	261.59	262.51
31	R	262.75 – 268.75	264.01	267.59	268.51
32	S	268.75 – 274.75	270.01	273.59	274.51
33	T	274.75 – 280.75	276.01	279.59	280.51
34	U	280.75 – 286.75	282.01	285.59	286.51
35	V	286.75 – 292.75	288.01	291.59	292.51
36	W	292.75 – 298.75	294.01	297.59	298.51
37	AA	298.75 – 304.75	300.02	303.60	304.52
38	BB	304.75 – 310.75	306.02	309.60	310.52
39	CC	310.75 – 316.75	312.02	315.60	316.52
40	DD	316.75 – 322.75	318.02	321.60	322.52
41	EE	322.75 – 328.75	324.02	327.60	328.52
42	FF	328.75 – 334.75	330.02	333.60	334.52
43	GG	334.75 – 340.75	336.02	339.60	340.52
44	HH	340.75 – 346.75	342.02	345.60	346.52
45	II	346.75 – 352.75	348.02	351.60	352.52
46	JJ	352.75 – 358.75	354.02	357.60	358.52
47	KK	358.75 – 364.75	360.02	363.60	364.52
48	LL	364.75 – 370.75	366.02	369.60	370.52
49	MM	370.75 – 376.75	372.02	375.60	376.52
50	NN	376.75 – 382.75	378.02	381.60	382.52
51	OO	382.75 – 388.75	384.02	387.60	388.52
52	PP	388.75 – 394.75	390.02	393.60	394.52
53	QQ	394.75 – 400.75	396.02	399.60	400.52
54	RR	400.75 – 406.75	402.02	405.60	406.52
55	SS	406.75 – 412.75	408.02	411.60	412.52
56	TT	412.75 – 418.75	414.02	417.60	418.52
57	UU	418.75 – 424.75	420.02	423.60	424.52
58	VV	424.75 – 430.75	426.02	429.60	430.52
59	WW	430.75 – 436.75	432.02	435.60	436.52
60	XX	436.75 – 442.75	438.02	441.60	442.52
61	YY	442.75 – 448.75	444.02	447.60	448.52

Harmonically Related Carriers (cont'd)

Channel Number/ Letter	Channel Bandedge (MHz)	Visual Carrier (MHz)	Chroma Carrier (MHz)	Aural Carrier (MHz)
62 ZZ	448.75 – 454.75	450.02	453.60	454.52
63	454.75 – 460.75	456.02	459.60	460.52
64	460.75 – 466.75	462.02	465.60	466.52
65	466.75 – 472.75	468.02	471.60	472.52
66	472.75 – 478.75	474.02	477.60	478.52
67	478.75 – 484.75	480.02	483.60	484.52
68	484.75 – 490.75	486.02	489.60	490.52
69	490.75 – 496.75	492.02	495.60	496.52
70	496.75 – 502.75	498.02	501.60	502.52
71	502.75 – 508.75	504.03	507.61	508.53
72	508.75 – 514.75	510.03	513.61	514.53
73	514.75 – 520.75	516.03	519.61	520.53
74	520.75 – 526.75	522.03	525.61	526.53
75	526.75 – 532.75	528.03	531.61	532.53
76	532.75 – 538.75	534.03	537.61	538.53
77	538.75 – 544.75	540.03	543.61	544.53
78	544.75 – 550.75	546.03	549.61	550.53
79	550.75 – 556.75	552.03	555.61	556.53
80	556.75 – 562.75	558.03	561.61	562.53
81	562.75 – 568.75	564.03	567.61	568.53
82	568.75 – 574.75	570.03	573.61	574.53
83	574.75 – 580.75	576.03	579.61	580.53
84	580.75 – 586.75	582.03	585.61	586.53
85	586.75 – 592.75	588.03	591.61	592.53
86	592.75 – 598.75	594.03	597.61	598.53
87	598.75 – 604.75	600.03	603.61	604.53
88	604.75 – 610.75	606.03	609.61	610.53
89	610.75 – 616.75	612.03	615.61	616.53
90	616.75 – 622.75	618.03	621.61	622.53
91	622.75 – 628.75	624.03	627.61	628.53
92	628.75 – 634.75	630.03	633.61	634.53
93	634.75 – 640.75	636.03	639.61	640.53
94	640.75 – 646.75	642.03	645.61	646.53
100	646.75 – 652.75	648.03	651.61	652.53
101	652.75 – 658.75	654.03	657.61	658.53
102	658.75 – 664.75	660.03	663.61	664.53
103	664.75 – 670.75	666.03	669.61	670.53
104	670.75 – 676.75	672.03	675.61	676.53

Harmonically Related Carriers (cont'd)

Channel Number/ Letter	Channel Bandedge (MHz)	Visual Carrier (MHz)	Chroma Carrier (MHz)	Aural Carrier (MHz)
105	676.75 – 682.75	678.03	681.61	682.53
106	682.75 – 688.75	684.03	687.61	688.53
107	688.75 – 694.75	690.03	693.61	694.53
108	694.75 – 700.75	696.03	699.61	700.53
109	700.75 – 706.75	702.04	705.62	706.54
110	706.75 – 712.75	708.04	711.62	712.54
111	712.75 – 718.75	714.04	717.62	718.54
112	718.75 – 724.75	720.04	723.62	724.54
113	724.75 – 730.75	726.04	729.62	730.54
114	730.75 – 736.75	732.04	735.62	736.54
115	736.75 – 742.75	738.04	741.62	742.54
116	742.75 – 748.75	744.04	747.62	748.54
117	748.75 – 754.75	750.04	753.62	754.54

2.3 UHF Channel Plan

UHF Related Carriers

Channel Number	Channel Bandedge (MHz)		Visual Carrier (MHz)	Chroma Carrier (MHz)	Aural Carrier (MHz)
14	470	476	471.25	474.83	475.75
15	476	482	477.25	480.83	481.75
16	482	488	483.25	486.83	487.75
17	488	494	489.25	492.83	493.75
18	494	500	495.25	498.83	499.75
19	500	506	501.25	504.83	505.75
20	506	512	507.25	510.83	511.75
21	512	518	513.25	516.83	517.75
22	518	524	519.25	522.83	523.75
23	524	530	525.25	528.83	529.75
24	530	536	531.25	534.83	535.75
25	536	542	537.25	540.83	541.75
26	542	548	543.25	546.83	547.75
27	548	554	549.25	552.83	553.75
28	554	560	555.25	558.83	559.75
29	560	566	561.25	564.83	565.75
30	566	572	567.25	570.83	571.75
31	572	578	573.25	576.83	577.75
32	578	584	579.25	582.83	583.75
33	584	590	585.25	588.83	589.75
34	590	596	591.25	594.83	595.75
35	596	602	597.25	600.83	601.75
36	602	608	603.25	606.83	607.75
37	608	614	609.25	612.83	613.75
38	614	620	615.25	618.83	619.75
39	620	626	621.25	624.83	625.75
40	626	632	627.25	630.83	631.75
41	632	638	633.25	636.83	637.75
42	638	644	639.25	642.83	643.75
43	644	650	645.25	648.83	649.75
44	650	656	651.25	654.83	655.75
45	656	662	657.25	660.83	661.75
46	662	668	663.25	666.83	667.75
47	668	674	669.25	672.83	673.75
48	674	680	675.25	678.83	679.75
49	680	686	681.25	684.83	685.75

UHF Related Carriers (cont'd)

Channel Number	Channel Bandedge (MHz)		Visual Carrier (MHz)	Chroma Carrier (MHz)	Aural Carrier (MHz)
50	686	692	687.25	690.83	691.75
51	692	698	693.25	696.83	697.75
52	698	704	699.25	702.83	703.75
53	704	710	705.25	708.83	709.75
54	710	716	711.25	714.83	715.75
55	716	722	717.25	720.83	721.75
56	722	728	723.25	726.83	727.75
57	728	734	729.25	732.83	733.75
58	734	740	735.25	738.83	739.75
59	740	746	741.25	744.83	745.75
60	746	752	747.25	750.83	751.75
61	752	758	753.25	756.83	757.75
62	758	764	759.25	762.83	763.75
63	764	770	765.25	768.83	769.75
64	770	776	771.25	774.83	775.75
65	776	782	777.25	780.83	781.75
66	782	788	783.25	786.83	787.75
67	788	794	789.25	792.83	793.75
68	794	800	795.25	798.83	799.75
69	806	812	801.25	804.83	805.75
70	812	818	807.25	810.83	811.75
71	818	824	813.25	816.83	817.75
72	824	830	819.25	822.83	823.75
73	830	836	825.25	828.83	829.75
74	836	842	831.25	834.83	835.75
75	842	848	837.25	840.83	841.75
76	848	854	843.25	846.83	847.75
77	854	860	849.25	852.83	853.75
78	860	866	855.25	858.83	859.75
79	866	872	861.25	864.83	865.75
80	872	878	867.25	870.83	871.75
81	878	884	873.25	876.83	877.75
82	884	890	879.25	882.83	883.75
83	890	896	885.25	888.83	889.75

2.4 FCC Rules and Regulations, Part 76

This section is a summary of FCC specifications that CATV systems are required to meet.

***Note**: The intention of this section is to summarize FCC specifications, not to replace them. Consult the current editions of all specifications and regulations for the complete and detailed requirements. (Refer to www.fcc.gov).*

All specifications in this handbook were taken from Title 47 Telecommunications, part 76.605 from the FCC. It summarizes the rule, standard, number of channels to be tested, frequency of testing, and equipment needed to perform each test. (It should be noted that although testing is required on a limited number of channels, all channels must conform to the specifications.)

From the FCC specifications Title 47 Telecommunications, part 76.601: "For cable television systems with 1,000 or more subscribers, but with 12,500 or less subscribers, proof-of-performance tests conducted pursuant to this section shall include measurements taken at six (6) widely separated points. However, within each cable system, one additional test point shall be added for every additional 12,500 subscribers or fraction thereof…chosen…to represent all geographic areas served…at least one-third…representative of subscriber terminals most distant…"

The headings/titles given to these rules are not those of the FCC. They are supplied here to help quickly identify what is covered by each rule.

Rule 76.605 (a)(2)	Aural Carrier Frequency
Standard	4.5 MHz ±5 kHz above the visual carrier, at the output of the modulating or processing equipment and at the subscriber terminal
Number of Channels	Seven, plus one channel for every 100 MHz, or fraction thereof, of upper band limit above 400 MHz *Ex: 10 channels for a 650 MHz system*
Frequency of Testing	Two times per year
Type of Equipment	Spectrum analyzer, frequency counter, or automated testing system

Rule 76.605 (a)(3)	Visual Carrier Frequency
Standard	0 dBmV at subscriber terminal and 3.0 dBmV at end of 100 ft. drop cable connected to the subscriber tap
Number of Channels	All NTSC or similar video channels
Frequency of Testing	Two times per year
Type of Equipment	SLM, system analyzer, spectrum analyzer, or automated test system

Rule 76.605 (a)(4)	24-Hour Visual Signal Level Variance Test
Standard	Level on each channel not to vary more than 8 dB within any 6-month interval including all tests in the 24-hour test period (measured at end of 100 ft. drop cable connected to the subscriber tap)
Number of Channels	All NTSC or similar video channels
Frequency of Testing	In July/August and January/February, one test per channel every six hours for a 24-hour period
Type of Equipment	SLM, system analyzer, spectrum analyzer, or automated test system

Rule 76.605 (a)(4)(i)	Adjacent Visual Carrier Level Variation
Standard	Within 3dB of any adjacent visual carrier within 6MHz
Number of Channels	All NTSC or similar video channels
Frequency of Testing	In July/August and January/February, one test each channel every six hours for a 24-hour test period
Type of Equipment	SLM, system analyzer, spectrum analyzer, or automated test system

Rule 76.605 (a)(4)(ii)	Visual Carrier Level Variation Over Entire Bandwidth
Standard	Within 10dB of the visual signal on any other channel for a system with an upper band limit of 300MHz, with a 1dB increase for each additional 100MHz of upper band limit: *Ex: 12dB for a 401-500MHz system; 13dB for a 501-600MHz system, etc.*
Number of Channels	All NTSC or similar video channels
Frequency of Testing	In July/August and January/February, one test each channel every six hours for a 24-hour test period
Type of Equipment	SLM, system analyzer, spectrum analyzer, or automated test system

Rule 76.605 (a)(4)(iii)	Maximum Visual Carrier Level
Standard	Carrier level that will not overload the subscriber's terminal or receiver
Number of Channels	All NTSC or similar video channels
Frequency of Testing	In July/August and January/February, one test each channel every six hours for each 24-hour test period
Type of Equipment	SLM, system analyzer, spectrum analyzer, or automated test system

Rule 76.605 (a)(5)	**Aural Signal Level**
Standard	At both the subscriber terminal and the headend output: 10 to 17 dB below the associated visual signal level. At a baseband converter: 6.5 to 17 dB below the associated visual signal level
Number of Channels	All NTSC or similar video channels
Frequency of Testing	Two times per year
Type of Equipment	SLM, system analyzer, spectrum analyzer, or automated test system

Rule 76.605 (a)(6)	**In-Band Frequency Response**
Standard	Within a range of ± 2 dB in the band from 0.75 to 5.0 MHz above the channel lower boundary, at the subscriber terminal
Number of Channels	Seven, plus one channel for every 100 MHz, or fraction thereof, upper band limit above 400 MHz *Ex: 11 channels for a 750 MHz system*
Frequency of Testing	Two times per year
Type of Equipment	Sweep transmitter/receiver, spectrum analyzer, or automated test system

Rule 76.605 (a)(7)	**Visual Carrier to Noise Ratio (CNR)**[1]
Standard	CNR shall not be less than 43 dB
Number of Channels	Seven, plus one channel for every 100 MHz, or fraction thereof, upper band limit above 400 MHz *Ex: 12 channels for an 862 MHz system*
Frequency of Testing	Two times per year
Type of Equipment	SLM, system analyzer, spectrum analyzer, or automated test system

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[1] For more information on CNR, see Section 3.2.1 on page 3-7.

Rule 76.605 (a)(8)	Carrier to Coherent Beats
Standard	Not less than 51 dB for non-coherent (standard) CATV systems, or not less than 47 dB for coherent (HRC/IRC) CATV systems
Number of Channels	Seven, plus one channel for every 100 MHz, or fraction thereof, upper band limit above 400 MHz *Ex: 10 channels for a 650 MHz system*
Frequency of Testing	Two times per year
Type of Equipment	SLM, system analyzer, spectrum analyzer, or automated test system

Rule 76.605 (a)(9)	Terminal Isolation
Standard	Not less than 18 dB (or manufacturer's specification) and sufficient to prevent subscriber-caused terminal reflections
Number of Channels	Seven, plus one channel for every 100 MHz, or fraction thereof, upper band limit above 400 MHz *Ex: 12 channels for an 862 MHz system*
Frequency of Testing	Two times per year
Type of Equipment	Manufacturer's specifications

Rule 76.605 (a)(10)	Hum Modulation
Standard	Not to exceed 3% of visual signal level
Number of Channels	One unmodulated channel
Frequency of Testing	Two times per year
Type of Equipment	SLM, system analyzer, spectrum analyzer, or automated test system

Rule 76.605(a)(11)(i)	Chrominance Luminance Delay
Standard	Within 170 ns
Number of Channels	Seven, plus one channel for every 100MHz, or fraction thereof, upper band limit above 400MHz *Ex: 9 channels for a 550MHz system*
Frequency of Testing	Once every three years (at headend)
Type of Equipment	Vectorscope, waveform monitor, or automated test system

Rule 76.605(a)(11)(ii)	Differential Gain
Standard	Not to exceed ± 20% of the maximum
Number of Channels	Seven, plus one channel for every 100MHz, or fraction thereof, upper band limit above 400MHz *Ex: 10 channels for a 650MHz system*
Frequency of Testing	Once every three years (at headend)
Type of Equipment	Vectorscope, waveform monitor, or automated test system

Rule 76.605(a)(11)(iii)	Differential Phase
Standard	Not to exceed ±10°
Number of Channels	Seven, plus one channel for every 100MHz, or fraction thereof, upper band limit above 400MHz *Ex: 11 channels for a 750MHz system*
Frequency of Testing	Once every three years (at headend)
Type of Equipment	Vectorscope, waveform monitor, or automated test system

Rule 76.605 (a)(12)	RF Signal Leakage Index (CLI)[1] Limit
Standard	< 54MHz and > 216MHz: 15μV/m @ 30m; 54 to 216MHz: 20μV/m @ 3m
Frequency of Testing	Quarterly
Type of Equipment	SLM, system analyzer, or spectrum analyzer and dipole, leakage field strength meter

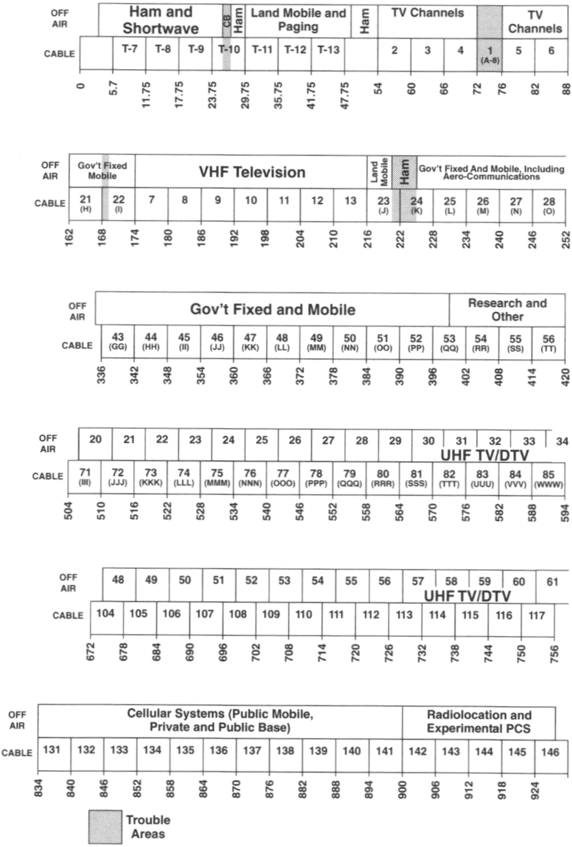
[1] For more information on CLI, see Section 4.1 on page 4-2.

2.5 Performance Standards

This is a summary of the FCC Proof of Performance Standards and is not intended as a replacement for those standards. Refer to the current edition of the FCC rules and regulations for definitive requirements (Title 47 Telecommunications Act, part 76.605).

Parameter	FCC Standard
Visual Signal at Subscriber Terminal	≥0 dBmV and ≥3.0 dBmV @ 100' Drop
CNR at Subscriber Terminal	≥43 dB
CTB at Subscriber Terminal	≥51 dB
CSO at Subscriber Terminal	≥51 dB
3 IM at Subscriber Terminal	≥51 dB
2 IM at Subscriber Terminal	≥51 dB
Hum Distortion (Incidental Modulation)	≤ 3%
Signal Leakage	
≤54 MHz	15 µV/m @ 30 m
54 to 216 MHz	20 µV/m @ 3 m
>216 MHz	15 µV/m @ 30 m
Freq Response (Peak to Valley)	
4.2 MHz	±2 dB
Total Signal Level Variation over Entire Frequency Range	≤10 dB over 300 MHz +1 dB per each additional 100 MHz *Ex: ≤15 dB over 750 MHz*
Isolation Port to Port	18 dB

2.6 Frequency Allocation Chart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CABLE
Ham and Shortwave
CB
Ham
Land Mobile and Paging
Ham
TV Channels
TV Channels
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OFF AIR
CABLE
Gov't Fixed Mobile
VHF Television
Land Mobile
Ham
Gov't Fixed And Mobile, Including Aero-Communications
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23 (J)
24 (K)
25 (L)
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162
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186
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OFF AIR
CABLE
Gov't Fixed and Mobile
Research and Other
43 (GG)
44 (HH)
45 (II)
46 (JJ)
47 (KK)
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OFF AIR
CABLE
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UHF TV/DTV
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CABLE
Cellular Systems (Public Mobile, Private and Public Base)
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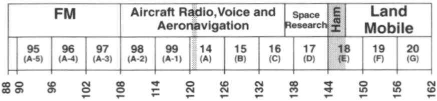
Trouble Areas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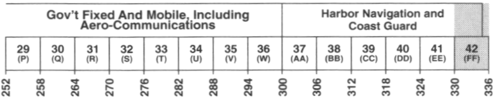
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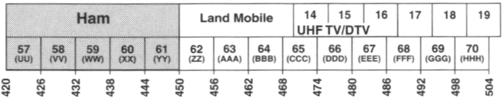
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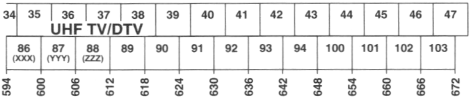
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88 (ZZZ)
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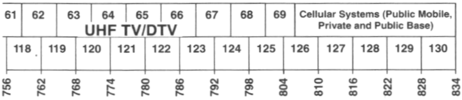
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UHF TV/DTV
Cellular Systems (Public Mobile, Private and Public Base)
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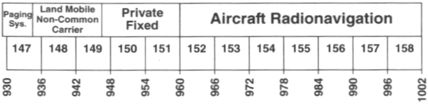
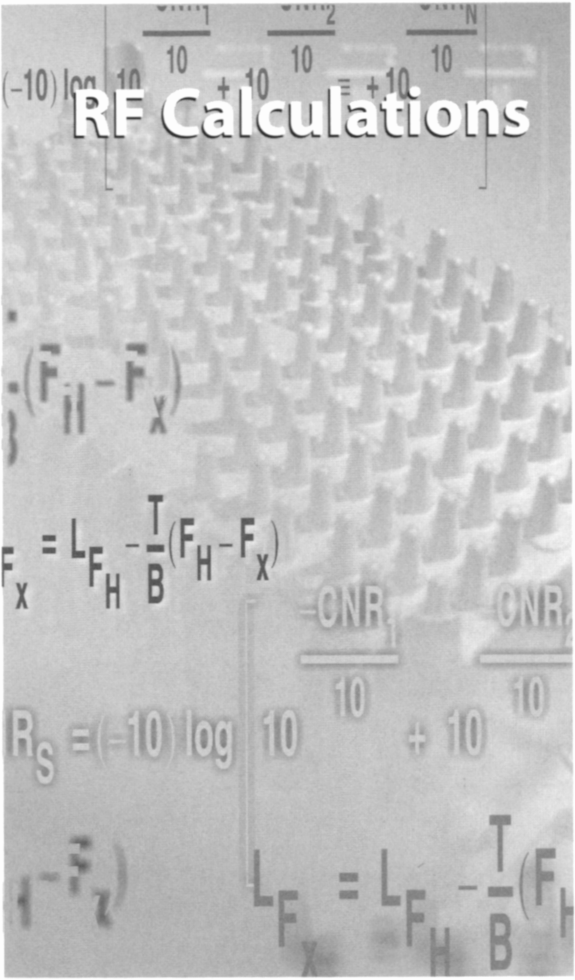
828
834


Paging Sys.
Land Mobile Non-Common Carrier
Private Fixed
Aircraft Radionavigation
147
148
149
150
151
152
153
154
155
156
157
158
930
936
942
948
954
960
966
972
978
984
990
996
1002

▨ Trouble Areas

RF Calculations



(−10) log
10
10
10
+ 10
+ 10
$L_{F_X} = L_{F_H} - \frac{T}{B}(F_H - F_X)$
CNR
CNR
10
10
$R_S = (-10) \log 10$
+ 10
$L_{F_X} = L_{F_H} - \frac{T}{B}(F_H$

3.1 Determining Carrier Levels

Determine balancing carrier levels by: Formula, Tilt Charts, and Calculation Chart.

3.1.1 Formula

Use the following formula to find the carrier output level (**L**) at a frequency (**Fx**), that is not a bandedge frequency

$$L_{F_x} = L_{F_H} - \frac{T}{B}(F_H - F_x)$$

where:

L_{F_x} = Level at the balancing carrier frequency (dB)

L_{F_H} = Level at the high bandedge frequency (dB)

T = System tilt (dB)

B = Band pass of the system (MHz)

F_H = High bandedge frequency (MHz)

F_x = Balancing carrier frequency (MHz)

3.1.2 Tilt Chart

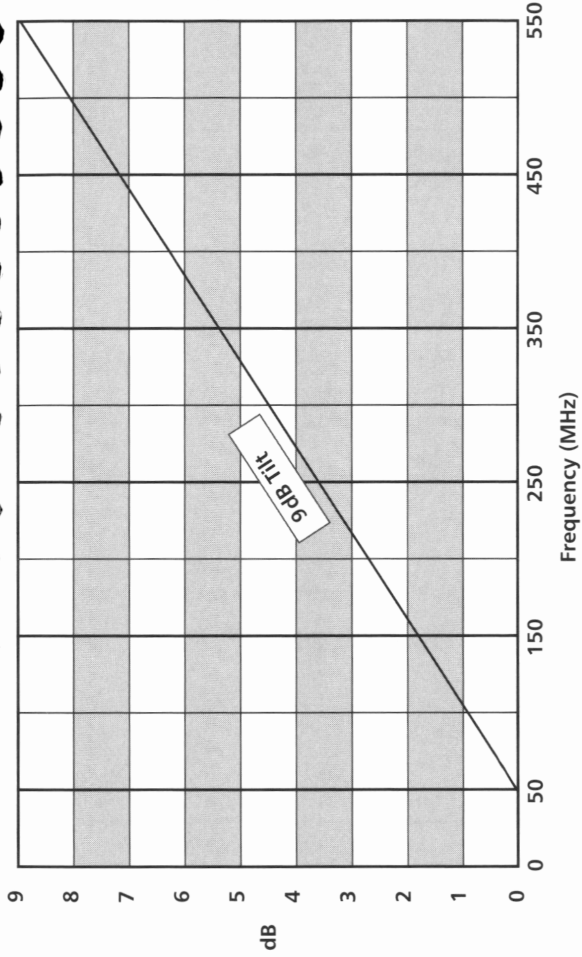
Determine the balancing carrier level using one of the following Tilt Charts. (Use the chart with the highest frequency matching that of your system—550MHz, 750MHz, or 862MHz.) Typical system tilts are shown on each chart. (If your system tilt is not on the chart, adapt the chart or use the blank chart on page 3-6.)

Use a straightedge to draw a line from the upper right-hand corner of the chart to the point on the left hand side of the chart that corresponds to your system tilt and lowest forward frequency.

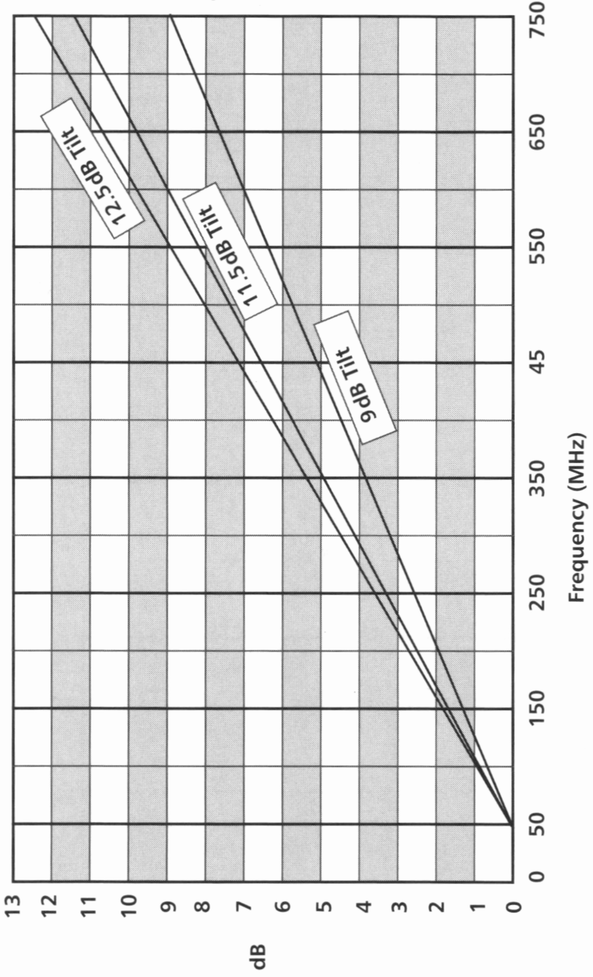
➤ ***To use the chart***

1. Find the point where the tilt line crosses the desired frequency.
2. From this point, read across to the dB level on the vertical axis. This is the loss, at the desired frequency, from the output level at the highest frequency.
3. Subtract this loss from the highest frequency output level to find the correct output level at the desired frequency.

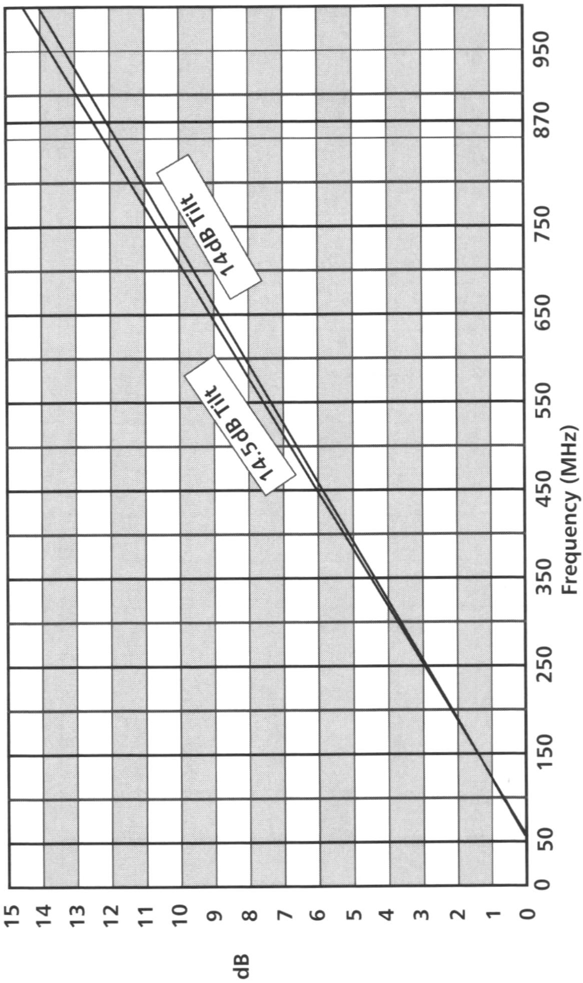
Amplifier Tilt—550 MHz



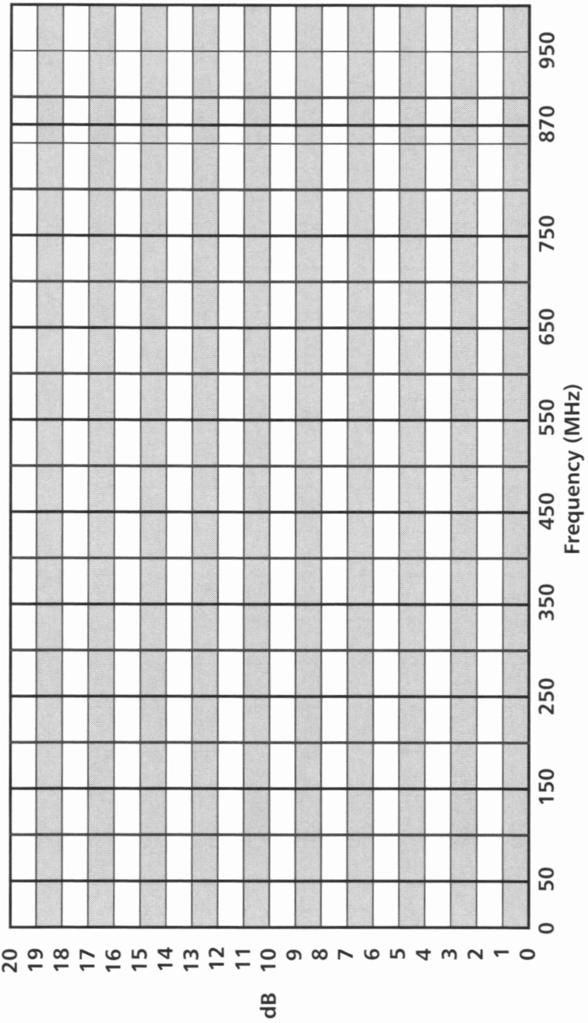
Amplifier Tilt—750 MHz



Amplifier Tilt—862 MHz



Amplifier Tilt Worksheet



3.2 System Performance Equations

3.2.1 Carrier to Noise Ratio (CNR) for NTSC Channels

CNR is a measurement of the noise power in a specific bandwidth relative to the video carrier level in the same bandwidth. CNR is specified over a 4 MHz band—the video portion of the channel. See the *CNR Measurement* figure on page 3-10.

CNR adds on a power basis. If the amplifier input level and the noise figure are known, CNR can be calculated with the following formulas.

CNR for a Single Amplifier:

$$\mathbf{CNR = Input\ Level(dBmV) + 59 - NF}$$

where **NF** = Noise Figure

➤ *To add similar CNR figures*

$$\mathbf{CNR_S = CNR_0 - 10 \log N}$$

where **N** = Number of **CNR** Figures

➤ *To add dissimilar* **CNR** *figures*

$$\mathbf{CNR_S = (-10)\log\left[10^{\frac{-CNR_1}{10}} + 10^{\frac{-CNR_2}{10}} \ldots + 10^{\frac{-CNR_N}{10}}\right]}$$

where:

CNR$_0$, CNR$_n$ = **CNR** (dB) of a Single Amplifier (**n** = 1, 2, 3, ...**N**)

CNR$_S$ = System **CNR** (dB)

59 = Thermal Noise in 4 MHz Bandwidth (dBmV)

N = Number of Amplifiers in Cascade

NF = Noise Figure (dB)

Note: Input level must be in dBmV.

If the Noise Figure does not include the equalizer at the amplifier input, add 1 dB to the Noise Figure. This will decrease CNR by about 1 dB.

Note: Every time you double a cascade of similar amplifiers, CNR degrades by 3 dB.

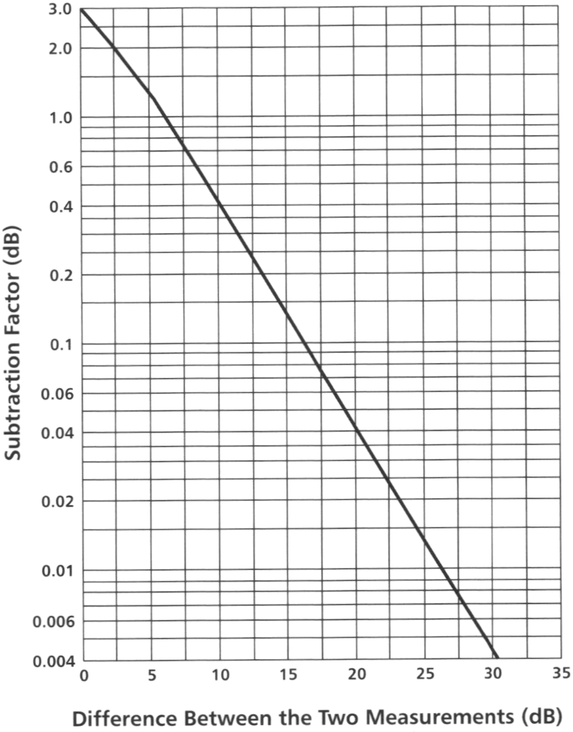
➤ ***To graphically add CNR figures***

Use the *Combining CNR or CSO Ratios* figure on page 3-9 to estimate the combined effects of two amplifiers with known CNR values.

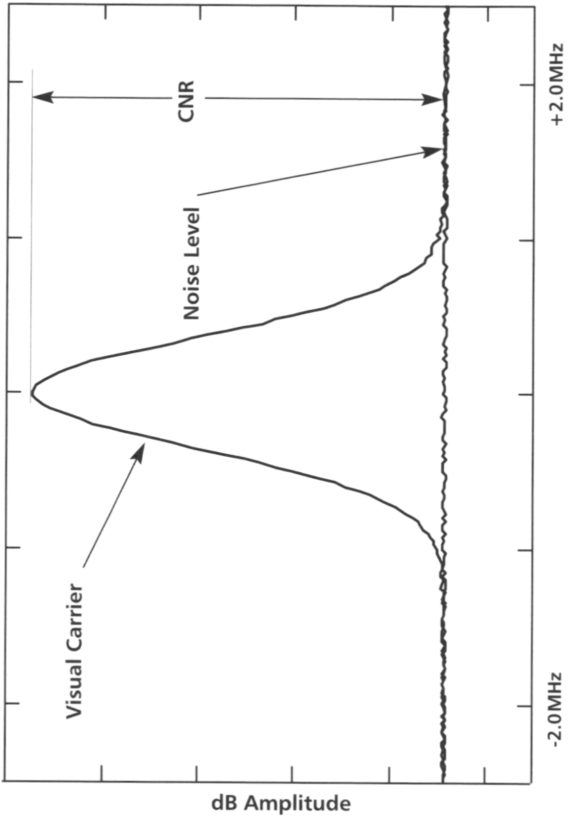
1. Calculate the CNR difference for the two amplifiers.
2. Locate the point corresponding to the difference between the two CNR values on the line graph.
3. Identify the "subtraction factor".
4. Subtract the "subtraction factor" from the lowest CNR value to obtain the combined CNR value.

The *CNR Measurement* figure on page 3-10 illustrates noise and the visual carrier in a 6 MHz channel. When measuring noise level, you must take into account several correction factors:

- Near noise floor (See "Spectrum Analyzer Error Correction Chart" on page 3-36)
- Frequency bandwidth to adjust for the resolution bandwidth
- A Log Conversion Shape supplied by the spectrum analyzer manufacturer.



Combining CNR or CSO Ratios



CNR Measurement

3.2.2 Composite Triple Beat (CTB)

CTB is the sum of the resultant beats produced by all combinations of $\pm f_1 \pm f_2 \pm f_3$ that occur at a specified frequency. In multichannel systems using push-pull amplifiers, CTB is usually the limiting performance factor. See the *CTB and CSO Beat Locations* figure on page 3-16 for the general locations of CTB beats.

CTB adds on a voltage basis. CTB ratios can be calculated as follows:

➤ ***To add similar CTB ratios***

$$\mathbf{CTB_S = CTB_0 - 20 \log N}$$

➤ ***To add dissimilar CTB ratios***

$$\mathbf{CTB_S = (-20) \log \left[10^{\frac{-CTB_1}{20}} + 10^{\frac{-CTB_2}{20}} \ldots + 10^{\frac{-CTB_N}{20}} \right]}$$

where:

$\mathbf{CTB_0, CTB_n}$ = **CTB** (dB) of a Single Amplifier (**n** = 1, 2, 3, ...**N**)

$\mathbf{CTB_S}$ = System **CTB** (dB)

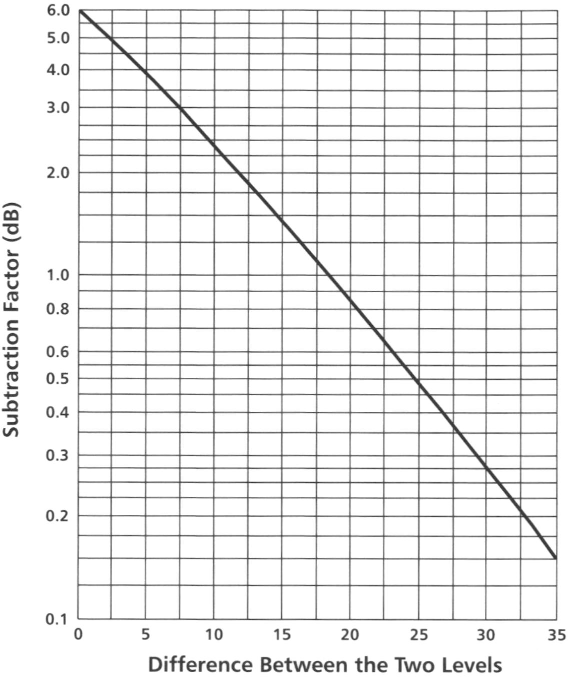
N = Number of amplifiers in cascade

> ***Note**: Doubling the number of amplifiers with identical CTB ratios degrades the total CTB by 6dB. Reducing the amplifier output by 1dB improves the CTB by about 2dB.*

➤ ***To graphically add CTB or Cross Modulation (XM) values***

Use the *Combining CTB or XM Values* figure on page 3-12 graph to estimate the combined effects of two amplifiers with known CNR values

1. Calculate the CNR difference for the two amplifiers.
2. Locate the point corresponding to the difference between the two CNR values on the line graph.
3. Identify the "subtraction factor".
4. Subtract the "subtraction factor" from the lowest CNR value to obtain the combined CNR value.



Combining CTB or XM Values

3.2.3 Cross Modulation (XM)

XM distortion is the result of modulation from one carrier imposed onto another carrier. XM calculations are identical to those of CTB.

XM adds on a voltage basis. CTB ratios can be calculated as follows:

➤ ***To add similar XM ratios***

$$XM_S = XM_0 - 20\log N$$

➤ ***To add dissimilar XM ratios***

$$XM_S = (-20)\log\left[10^{\frac{-XM_1}{20}} + 10^{\frac{-XM_2}{20}} \ldots + 10^{\frac{-XM_N}{20}}\right]$$

where:

$\mathbf{XM_S}$ = System **XM** (dB)

$\mathbf{XM_0}$, $\mathbf{XM_n}$= **XM** (dB) of a Single Amplifier (**n** = 1, 2, 3, ...**N**)

N = Number of Amplifiers in Cascade

Doubling the number of amplifiers with identical XM ratios degrades the total XM by 6dB. Reducing the amplifier output by about 1dB improves the XM by about 2dB.

3.2.4 Composite Second Order (CSO)

CSO is the distortion caused by the beats which result from all the possible combinations of two frequencies, $\pm f_1$ $\pm f_1$. See the *CTB and CSO Beat Locations* figure on page 3-16 for the general locations of CSO beats.

CSO adds on a power basis. CSO can be calculated as follows.

➤ ***To add similar CSO ratios***

$$CSO_S = CSO_0 - 10\log N$$

➤ ***To add dissimilar CSO figures***

$$CSO_S = (-10)\log\left[10^{\frac{-CSO_1}{10}} + 10^{\frac{-CSO_2}{10}} \ldots + 10^{\frac{-CSO_N}{10}}\right]$$

where:

CSO_S = System **CSO** (dB)

CSO_n, CSO_n = **CSO** (dB) of a Single Amplifier (**n** = 1, 2, 3, ...**N**)

N = Number of Amplifiers in Cascade

> ***Note***: *Reducing amplifier output by 1 dB improves CSO by about 1 dB.*
>
> ***Note***: *Every time you double a cascade of similar amplifiers, CSO degrades by 3 dB.*

3.3 Output Level on Performance

As output levels increase, CNR (Carrier-to-Noise Ratio) improves while CSO (Composite Second Order), CTB (Composite Triple Beat), and XM (Cross Modulation) degrade. As output levels decrease, CNR degrades, while CSO, CTB, and XM improve.

As a general rule, for every 1 dB *increase* in output level, CNR *increases* by 1 dB, CSO *decreases* by 1 dB, while CTB and XM *decrease* by 2 dB.

The **CNR** relationship to output for an amplifier is given by:

$$CNR_1 \quad CNR_0 \quad (L_1 \quad L_0)$$

where:

CNR_0 = Amplifier **CNR** at Level L_0 (dB)

CNR_1 = Amplifier **CNR** at (new) Level L_1 (dB)

The **CSO** relationship to output for an amplifier is given by:

$$\mathbf{CSO_1 = CSO_0 \quad L_1 \quad L_0}$$

where:

CSO_0 = Amplifier **CSO** at Level **L_0** (dB)
CSO_1 = Amplifier **CSO** at new Level **L_1** (dB)

The **CTB** (or **XM**) relationship to output for an amplifier is given by:

$$\mathbf{CTB_1 \quad CTB_0 \quad 2\,L_1 \quad L_0}$$

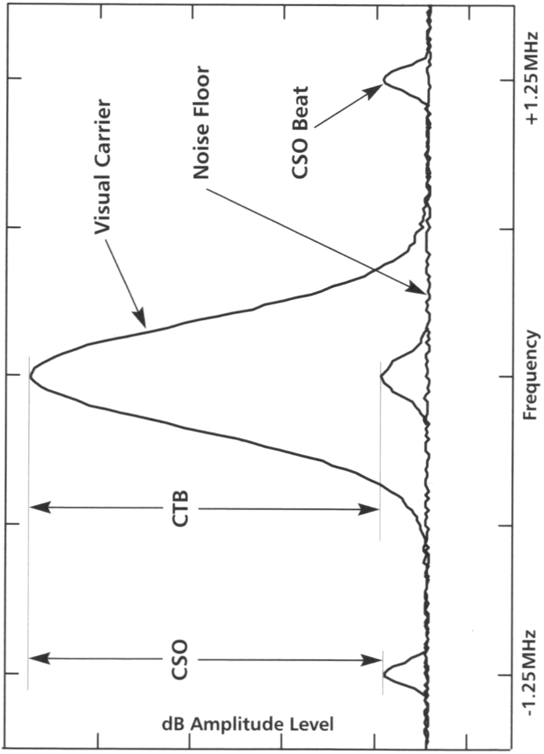
where:

CTB_0 = Amplifier **CTB** at Level **L_0** (dB)
CTB_1 = Amplifier **CTB** at new Level **L_1** (dB)

3.4 CSO and CTB

Composite Second Order (CSO) beats fall 1.25 MHz above and below the visual carrier. Composite Triple Beats (CTB) fall directly under the carrier as shown below. Not shown are CSO beats that may also occur at 0.75 MHz above and below the carrier at lower amplitudes.

FCC specifications require that the beats be a *minimum* of 51 dB below the carrier level. See reference to measurement correction factors on page 3-10.


Visual Carrier
Noise Floor
CSO Beat
+1.25MHz
Frequency
-1.25MHz
CTB
CSO
dB Amplitude Level

CTB and CSO Beat Locations

The following table gives the number of beats that accumulate at specific frequencies due to CTB and CSO for 60, 77, 96, 112, and 131 channel systems.

System CTB and CSO for 60, 77, and 96 NTSC Channels

Visual Carrier Freq.	450MHz 60 Channels		550MHz 77 Channels			650MHz 96 Channels		
	CTB	CSO	CTB	CSO −1.25	CSO +1.25	CTB	CSO −1.25	CSO +1.25
55.25	615	2	1235	68	0	1903	85	0
61.25	640	2	1271	67	0	1946	84	0
67.25	661	2	1301	66	0	1986	83	0
77.25[1]	56	45	1437	64	0	2156	81	0
83.25[1]	56	44	1470	63	0	2196	80	0
121.25	868	2	1602	57	3	2362	74	3
127.25	894	2	1632	56	2	2402	73	2
133.25	918	2	1662	55	1	2439	72	1
139.25	939	2	1690	54	0	2477	71	0
145.25	960	2	1718	53	0	2512	70	0
151.25	979	2	1744	52	0	2548	69	0
157.25	998	2	1771	51	0	2582	68	0
163.25	1015	2	1796	50	2	2617	67	2
169.25	1032	2	1822	49	4	2650	66	4
175.25	1048	2	1845	48	6	2683	65	6
181.25	1064	2	1869	47	6	2714	64	6
187.25	1079	3	1890	46	6	2745	63	6
193.25	1093	3	1912	45	6	2774	62	6
199.25	1106	3	1931	44	6	2803	61	6
205.25	1118	3	1951	43	6	2830	60	6
211.25	1129	3	1968	42	6	2857	59	6
217.25	1139	3	1986	41	7	2882	58	7
223.25	1148	3	2001	40	8	2907	57	8
229.25	1156	3	2017	39	9	2930	56	9
235.25	1163	3	2030	38	10	2953	55	10
241.25	1169	4	2044	37	11	2974	54	11
247.25	1174	4	2055	36	12	2995	53	12
253.25	1178	5	2067	35	13	3014	52	13
259.25	1181	5	2076	34	14	3033	51	14
265.25	1183	6	2086	33	15	3050	50	15
271.25	1184	6	2093	32	16	3067	49	16
277.25	1184	7	2101	31	17	3082	48	17
283.25	1183	7	2106	30	18	3097	47	18

System CTB and CSO for 60, 77, and 96 NTSC Channels

Visual Carrier Freq.	450MHz 60 Channels		550MHz 77 Channels			650MHz 96 Channels		
	CTB	CSO	CTB	CSO −1.25	CSO +1.25	CTB	CSO −1.25	CSO +1.25
289.25	1181	8	2112	29	19	3110	46	19
295.25	1178	8	2115	28	20	3123	45	20
301.25	1174	9	2119	27	21	3134	44	21
307.25	1169	9	2120	26	22	3145	43	22
313.25	1163	10	2122	25	23	3154	42	23
319.25	1156	10	2121	24	24	3163	41	24
325.25	1148	11	2121	23	25	3170	40	25
331.25	1139	11	2118	22	26	3177	39	26
337.25	1129	12	2116	21	27	3182	38	27
343.25	1118	12	2111	20	28	3187	37	28
349.25	1106	13	2107	19	29	3190	36	29
355.25	1093	13	2100	18	30	3193	35	30
361.25	1079	14	2094	17	31	3194	34	31
367.25	1064	14	2085	16	32	3195	33	32
373.25	1048	15	2077	15	33	3194	32	33
379.25	1031	15	2066	14	34	3193	31	34
385.25	1013	16	2056	13	35	3190	30	35
391.25	995	16	2043	12	36	3187	29	36
397.25	977	17	2031	11	37	3182	28	37
403.25	959	17	2016	10	38	3177	27	38
409.25	940	18	2002	9	39	3170	26	39
415.25	920	18	1985	8	40	3163	25	40
421.25	899	19	1969	7	41	3154	24	41
427.25	877	19	1950	6	42	3145	23	42
433.25	854	20	1932	5	43	3134	22	43
439.25	829	20	1911	4	44	3123	21	44
445.25	801	21	1891	3	45	3110	20	45
451.25	–	–	1868	3	46	3097	19	46
457.25	–	–	1846	3	47	3082	18	47
463.25	–	–	1821	3	48	3067	17	48
469.25	–	–	1797	3	49	3050	16	49
475.25	–	–	1770	3	50	3033	15	50
481.25	–	–	1744	3	51	3014	14	51
487.25	–	–	1715	2	52	2995	13	52
493.25	–	–	1687	1	53	2974	12	53
499.25	–	–	1656	0	54	2953	11	54
505.25	–	–	1627	0	55	2930	10	55

System CTB and CSO for 60, 77, and 96 NTSC Channels

Visual Carrier Freq.	450MHz 60 Channels		550MHz 77 Channels			650MHz 96 Channels		
	CTB	CSO	CTB	CSO −1.25	CSO +1.25	CTB	CSO −1.25	CSO +1.25
511.25	–	–	1596	0	56	2907	9	56
517.25	–	–	1567	0	57	2882	8	57
523.25	–	–	1535	0	58	2857	7	58
529.25	–	–	1504	0	59	2830	6	59
535.25	–	–	1470	0	60	2803	5	60
541.25	–	–	1436	0	61	2774	4	61
547.25	–	–	1398	0	62	2745	3	62
553.25	–	–	–	–	–	2714	3	63
559.25	–	–	–	–	–	2683	3	64
565.25	–	–	–	–	–	2650	3	65
571.25	–	–	–	–	–	2617	3	66
577.25	–	–	–	–	–	2582	3	67
583.25	–	–	–	–	–	2547	3	68
589.25	–	–	–	–	–	2510	2	69
595.25	–	–	–	–	–	2473	1	70
601.25	–	–	–	–	–	2434	0	71
607.25	–	–	–	–	–	2396	0	72
613.25	–	–	–	–	–	2357	0	73
619.25	–	–	–	–	–	2319	0	74
625.25	–	–	–	–	–	2279	0	75
631.25	–	–	–	–	–	2239	0	76
637.25	–	–	–	–	–	2197	0	77
643.25	–	–	–	–	–	2154	0	78
649.25	–	–	–	–	–	2108	0	79

1. Because NTSC channels 5 and 6 do not fall at the regular 6MHz spacing, beats are offset from the normal beat locations by +2.0MHz (i.e., CTB is located at +2.0MHz, and CSO products are located at +0.75 and +3.75MHz from the carrier.

System CTB and CSO for 112 and 131 NTSC Channels

Visual Carrier Freq.	750MHz 112 Channels			860MHz 131 Channels		
	CTB	CSO −1.25	CSO +1.25	CTB	CSO −1.25	CSO +1.25
55.25	2663	101	0	3731	120	0
61.25	2714	100	0	3793	119	0
67.25	2762	99	0	3849	118	0
77.25[1]	2964	97	0	4089	116	0
83.25[1]	3012	96	0	4148	115	0
121.25	3210	90	3	4384	109	3
127.25	3258	89	2	4440	108	2
133.25	3303	88	1	4496	107	1
139.25	3349	87	0	4550	106	0
145.25	3392	86	0	4604	105	0
151.25	3436	85	0	4656	104	0
157.25	3478	84	0	4709	103	0
163.25	3521	83	2	4760	102	2
169.25	3562	82	4	4812	101	4
175.25	3603	81	6	4861	100	6
181.25	3642	80	6	4911	99	6
187.25	3681	79	6	4958	98	6
193.25	3718	78	6	5006	97	6
199.25	3755	77	6	5051	96	6
205.25	3790	76	6	5097	95	6
211.25	3825	75	6	5140	94	6
217.25	3858	74	7	5184	93	7
223.25	3891	73	8	5225	92	8
229.25	3922	72	9	5267	91	9
235.25	3953	71	10	5306	90	10
241.25	3982	70	11	5346	89	11
247.25	4011	69	12	5383	88	12
253.25	4038	68	13	5421	87	13
259.25	4065	67	14	5456	86	14
265.25	4090	66	15	5492	85	15
271.25	4115	65	16	5525	84	16
277.25	4138	64	17	5559	83	17
283.25	4161	63	18	5590	82	18
289.25	4182	62	19	5622	81	19
295.25	4203	61	20	5651	80	20
301.25	4222	60	21	5681	79	21

System CTB and CSO for 112 and 131 NTSC Channels

Visual Carrier Freq.	750MHz 112 Channels			860MHz 131 Channels		
	CTB	CSO −1.25	CSO +1.25	CTB	CSO −1.25	CSO +1.25
307.25	4241	59	22	5708	78	22
313.25	4258	58	23	5736	77	23
319.25	4275	57	24	5761	76	24
325.25	4290	56	25	5787	75	25
331.25	4305	55	26	5810	74	26
337.25	4318	54	27	5834	73	27
343.25	4331	53	28	5855	72	28
349.25	4342	52	29	5877	71	29
355.25	4353	51	30	5896	70	30
361.25	4362	50	31	5916	69	31
367.25	4371	49	32	5933	68	32
373.25	4378	48	33	5951	67	33
379.25	4385	47	34	5966	66	34
385.25	4390	46	35	5982	65	35
391.25	4395	45	36	5995	64	36
397.25	4398	44	37	6009	63	37
403.25	4401	43	38	6020	62	38
409.25	4402	42	39	6032	61	39
415.25	4403	41	40	6041	60	40
421.25	4402	40	41	6051	59	41
427.25	4401	39	42	6058	58	42
433.25	4398	38	43	6066	57	43
439.25	4395	37	44	6071	56	44
445.25	4390	36	45	6077	55	45
451.25	4385	35	46	6080	54	46
457.25	4378	34	47	6084	53	47
463.25	4371	33	48	6085	52	48
469.25	4362	32	49	6087	51	49
475.25	4353	31	50	6086	50	50
481.25	4342	30	51	6086	49	51
487.25	4331	29	52	6083	48	52
493.25	4318	28	53	6081	47	53
499.25	4305	27	54	6076	46	54
505.25	4290	26	55	6072	45	55
511.25	4275	25	56	6065	44	56
517.25	4258	24	57	6059	43	57
523.25	4241	23	58	6050	42	58

System CTB and CSO for 112 and 131 NTSC Channels

Visual Carrier Freq.	750MHz 112 Channels			860MHz 131 Channels		
	CTB	CSO −1.25	CSO +1.25	CTB	CSO −1.25	CSO +1.25
529.25	4222	22	59	6042	41	59
535.25	4203	21	60	6031	40	60
541.25	4182	20	61	6021	39	61
547.25	4161	19	62	6008	38	62
553.25	4138	18	63	5996	37	63
559.25	4115	17	64	5981	36	64
565.25	4090	16	65	5967	35	65
571.25	4065	15	66	5950	34	66
577.25	4038	14	67	5934	33	67
583.25	4011	13	68	5915	32	68
589.25	3982	12	69	5897	31	69
595.25	3953	11	70	5876	30	70
601.25	3922	10	71	5856	29	71
607.25	3891	9	72	5833	28	72
613.25	3858	8	73	5811	27	73
619.25	3825	7	74	5786	26	74
625.25	3790	6	75	5762	25	75
631.25	3755	5	76	5735	24	76
637.25	3718	4	77	5709	23	77
643.25	3681	3	78	5680	22	78
649.25	3642	3	79	5652	21	79
655.25	3603	3	80	5621	20	80
661.25	3562	3	81	5591	19	81
667.25	3521	3	82	5558	18	82
673.25	3478	3	83	5526	17	83
679.25	3435	3	84	5491	16	84
685.25	3390	2	85	5457	15	85
691.25	3345	1	86	5420	14	86
697.25	3298	0	87	5384	13	87
703.25	3252	0	88	5345	12	88
709.25	3205	0	89	5307	11	89
715.25	3159	0	90	5266	10	90
721.25	3111	0	91	5226	9	91
727.25	3063	0	92	5183	8	92
733.25	3013	0	93	5141	7	93
739.25	2962	0	94	5096	6	94
745.25	2908	0	95	5052	5	95

System CTB and CSO for 112 and 131 NTSC Channels

Visual Carrier Freq.	750MHz 112 Channels			860MHz 131 Channels		
	CTB	CSO −1.25	CSO +1.25	CTB	CSO −1.25	CSO +1.25
751.25	–	–	–	5005	4	96
757.25	–	–	–	4959	3	97
763.25	–	–	–	4910	3	98
769.25	–	–	–	4862	3	99
775.25	–	–	–	4811	3	100
781.25	–	–	–	4761	3	101
787.25	–	–	–	4708	3	102
793.25	–	–	–	4656	3	103
799.25	–	–	–	4601	2	104
805.25	–	–	–	4547	1	105
811.25	–	–	–	4490	0	106
817.25	–	–	–	4435	0	107
823.25	–	–	–	4378	0	108
829.25	–	–	–	4323	0	109
835.25	–	–	–	4265	0	110
841.25	–	–	–	4208	0	111
847.25	–	–	–	4148	0	112
853.25	–	–	–	4088	0	113
859.25	–	–	–	4024	0	114

1. Because NTSC channels 5 and 6 do not fall at the regular 6MHz spacing, beats are offset from the normal beat locations by +2.0MHz (i.e., CTB is located at +2.0MHz, and CSO products are located at +0.75 and +3.75MHz from the carrier.

System CTB and CSO for 29, 35, & 42 CENELEC Channels

Visual Carrier Freq.	600MHz 29 Channels			750MHz 35 Channels			860MHz 42 Channels		
	CTB	CSO −0.75	CSO +0.75	CTB	CSO −0.75	CSO +0.75	CTB	CSO −0.75	CSO +0.75
48.25[1]	0	0	0	0	0	0	0	0	0
119.25	71	0	14	100	0	15	147	0	15
175.25	106	0	7	159	0	8	199	0	12
191.25	117	0	7	170	0	7	210	0	11
207.25	122	0	6	171	0	6	211	0	9
223.25	114	0	6	156	0	7	197	0	10

System CTB and CSO for 29, 35, & 42 CENELEC Channels

Visual Carrier Freq.	600MHz 29 Channels			750MHz 35 Channels			860MHz 42 Channels		
	CTB	CSO –0.75	CSO +0.75	CTB	CSO –0.75	CSO +0.75	CTB	CSO –0.75	CSO +0.75
231.25	88	0	7	130	0	12	209	0	14
247.25	102	0	5	151	0	9	231	0	12
263.25	107	0	4	160	0	7	238	0	11
287.25	108	0	6	133	0	11	184	0	12
311.25	131	2	2	186	2	2	270	2	9
327.25	139	2	1	199	2	1	284	2	7
343.25	143	2	2	204	2	2	289	2	7
359.25	141	0	3	206	0	3	289	0	7
375.25	140	0	4	206	0	5	287	0	8
391.25	139	0	4	207	0	5	288	0	7
407.25	135	4	3	203	4	4	285	4	5
423.25	124	4	2	190	4	3	275	4	3
439.25	107	6	0	167	6	2	255	6	2
447.25	127	3	1	180	3	4	244	3	11
463.25	138	5	1	199	5	4	262	5	10
479.25	140	6	1	207	6	4	269	6	9
495.25	135	7	0	208	7	2	269	7	7
511.25	130	6	0	209	6	1	272	6	6
527.25	121	3	0	204	3	0	272	3	5
543.25	106	4	0	189	4	1	265	4	5
567.25	91	10	0	142	10	1	233	10	5
583.25	97	10	0	151	10	0	243	10	4
599.25	92	12	0	151	12	0	241	12	4
663.25	–	–	–	159	6	0	257	6	2
679.25	–	–	–	163	4	0	268	4	1
695.25	–	–	–	157	6	0	266	6	0
711.25	–	–	–	148	8	0	264	8	0
727.25	–	–	–	133	8	0	258	8	0
743.25	–	–	–	116	8	0	257	8	0
759.25	–	–	–	–	–	–	248	12	0
775.25	–	–	–	–	–	–	239	16	0
791.25	–	–	–	–	–	–	226	16	0
807.25	–	–	–	–	–	–	217	14	0
823.25	–	–	–	–	–	–	208	12	0
839.25	–	–	–	–	–	–	198	14	0
855.25	–	–	–	–	–	–	179	20	0

1. Because CENELEC channel at 48.25 MHz does not fall at the regular 8 MHz spacing, beats are offset from the normal beat locations by –2.0 MHz (i.e., CTB is located at –2.0 MHz, and CSO products are located at –1.75 and –0.25 MHz from the carrier.

System CTB and CSO for 63 and 76 PAL B/G Channels

Visual Carrier Freq. (MHz)	550 MHz 63 Channels			650 MHz 76 Channels		
	CTB	CSO –0.75	CSO +0.75	CTB	CSO –0.75	CSO +0.75
48.25	183	26[1]	21	235	39[1]	21
55.25	188	11	44	288	1[1]	57
62.25	185	1[1]	29[2]	237	1[1]	42[2]
69.25	181	1[1]	24[3]	220	1[1]	37[3]
76.25	172	1[1]	23[4]	211	1[1]	36[4]
112.25	273	30[1]	7	325	43[1]	7
119.25	310	12[1]	23	462	12[1]	36
126.25	302	11[1]	18[2]	354	11[1]	31[2]
133.25	305	10[1]	17[3]	344	10[1]	30[3]
140.25	312	9[1]	16[4]	351	9[1]	29[4]
147.25	297	8[1]	7	323	8[1]	7
154.25	302	7[1]	7	328	7[1]	7
161.25	310	14[5]	7	336	27[5]	7
168.25	355	16[1]	8	407	29[1]	8
175.25	424	6	17	623	6	30
182.25	364	8	12[2]	416	8	25[2]
189.25	351	10	11[3]	390	10	24[3]
196.25	351	10	10[4]	390	10	23[4]
203.25	336	10	8	362	10	8
210.25	335	10	8	361	10	8
217.25	336	10	8	362	21[5]	8
224.25	361	10	8	413	20[1]	8
231.25	492	10	9	735	10	22
238.25	357	10	6	409	10	18[2]
245.25	330	10	5[3]	369	10	18[3]
252.25	324	10	5[6]	363	10	17[4]
259.25	309	10	6	335	10	6[6]
266.25	302	10	7[6]	328	10	7[6]
273.25	295	10	8[6]	321	15	8[6]
280.25	298	10	9[6]	350	14[1]	9[6]
287.25	511	10	10[6]	801	10	13
294.25	273	10	11	325	10	12[2]

System CTB and CSO for 63 and 76 PAL B/G Channels

Visual Carrier Freq. (MHz)	550MHz 63 Channels			650MHz 76 Channels		
	CTB	CSO –0.75	CSO +0.75	CTB	CSO –0.75	CSO +0.75
303.25	349	4^{1}	4	652	5^{1}	11
311.25	360	4^{1}	10^{7}	667	5^{1}	10
319.25	365	4^{1}	15^{7}	682	5^{1}	15^{7}
327.25	375	3^{1}	16^{8}	696	5^{1}	16^{8}
335.25	381	3^{1}	17^{9}	709	5^{1}	17^{9}
343.25	489	10	18^{6}	821	10	18^{6}
351.25	456	19	3	795	19	5
359.25	418	3^{1}	3	761	5^{1}	5
367.25	425	3^{1}	3	775	5^{1}	4
375.25	425	3^{1}	23^{7}	783	4^{1}	23^{7}
383.25	424	2	24^{8}	791	4^{1}	24^{8}
391.25	427	2	25^{9}	797	4^{1}	25^{9}
399.25	463	2	28^{6}	839	4^{1}	28^{6}
407.25	472	29	2	851	29	4
415.25	437	2	4^{6}	823	4^{1}	4
423.25	441	4	4^{6}	828	4	4^{6}
431.25	433	4	23^{7}	831	4	23^{7}
439.25	421	4	22^{8}	833	4	22^{8}
447.25	416	4	21^{9}	834	4	21^{9}
455.25	417	4	24^{6}	838	4	24^{6}
463.25	430	23	4^{6}	857	23	4^{6}
471.25	404	4	6^{6}	834	4	6^{6}
479.25	400	6	6^{6}	832	6	6^{6}
487.25	389	6	17^{7}	826	6	17^{7}
495.25	361	6	16^{8}	823	6	16^{8}
503.25	353	6	15^{9}	818	6	15^{9}
511.25	342	6	18^{6}	813	6	18^{6}
519.25	336	17	6^{6}	810	17	6^{6}
527.25	319	6	8^{6}	799	6	8^{6}
535.25	310	8	8^{6}	789	8	8^{6}
543.25	297	8	11^{7}	770	8	11^{7}
551.25	–	–	–	760	8	10^{8}
559.25	–	–	–	751	8	9^{9}
567.25	–	–	–	739	8	12^{6}
575.25	–	–	–	728	11	8^{6}
583.25	–	–	–	714	8	10^{6}
591.25	–	–	–	697	10	10^{6}

System CTB and CSO for 63 and 76 PAL B/G Channels

Visual Carrier Freq. (MHz)	550MHz 63 Channels			650MHz 76 Channels		
	CTB	CSO –0.75	CSO +0.75	CTB	CSO –0.75	CSO +0.75
599.25	–	–	–	663	10	10[6]
607.25	–	–	–	649	11	10[6]
615.25	–	–	–	632	12	10[6]
623.25	–	–	–	616	13	10[6]
631.25	–	–	–	597	14	10[6]
639.25	–	–	–	579	15	10[6]
647.25	–	–	–	560	16	10[6]

1. Maximum beats are located at –0.25MHz from carrier.
2. Maximum beats are located at+1.75MHz from carrier.
3. Maximum beats are located at +2.75MHz from carrier.
4. Maximum beats are located at+3.75MHz from carrier.
5. Maximum beats are located at –1.25MHz from carrier.
6. Maximum beats are located at +0.25MHz from carrier.
7. Maximum beats are located at +3.25MHz from carrier.
8. Maximum beats are located at +2.25MHz from carrier.
9. Maximum beats are located at +1.25MHz from carrier.

System CTB and CSO for 88 and 102 PAL B/G Channels

Visual Carrier Freq. (MHz)	550MHz 88 Channels			650MHz 102 Channels		
	CTB	CSO –0.75	CSO +0.75	CTB	CSO –0.75	CSO +0.75
48.25	399[1]	51[2]	21	693[1]	65[2]	21
55.25	456	1	69	743	1[2]	83
62.25	533[3]	[1]	54[4]	841[3]	1[2]	68[4]
69.25	442[5]	1	49[6]	757[5]	1[2]	63[6]
76.25	460[7]	1	48[8]	782[7]	1[2]	62[8]
112.25	620[1]	55[2]	7	970[1]	69[2]	7
119.25	678	12[2]	48	1021	12[2]	62
126.25	563[3]	11[2]	43[4]	927[3]	11[2]	57[4]
133.25	584[5]	10[2]	42[6]	955[5]	10[2]	56[6]
140.25	604[7]	9[2]	41[8]	982[7]	9[2]	55[8]
147.25	623[9]	8[2]	7	1008[9]	8[2]	7
154.25	352	7[2]	7	380	7[2]	7
161.25	360	39[10]	7	388	53[10]	7
168.25	714[1]	41[2]	8	1113[1]	55[2]	8
175.25	881	6	42	1273	6	56

System CTB and CSO for 88 and 102 PAL B/G Channels

Visual Carrier Freq. (MHz)	550MHz 88 Channels			650MHz 102 Channels		
	CTB	CSO –0.75	CSO +0.75	CTB	CSO –0.75	CSO +0.75
182.25	709[3]	8	37[4]	1122[3]	8	51[4]
189.25	732[5]	10	36[6]	1152[5]	10	50[6]
196.25	752[7]	10	35[8]	1179[7]	10	49[8]
203.25	774[9]	10	8	1208[9]	10	8
210.25	385	10	8	413	10	8
217.25	386	33[10]	8	414	47[10]	8
224.25	832[1]	32[2]	8	1280[1]	46[2]	8
231.25	1035	10	34	1476	10	48
238.25	890[3]	10	30[4]	1352[3]	10	44[4]
245.25	901[5]	10	30[6]	1370[5]	10	44[6]
252.25	924[7]	10	29[8]	1400[7]	10	43[8]
259.25	946[9]	10	6[11]	1429[9]	10	6[11]
266.25	352	10	7[11]	380	10	7[11]
273.25	345	27[10]	8[11]	373	41[10]	8[11]
280.25	991[1]	26[2]	9[11]	1488[1]	40[2]	9[11]
287.25	1143	10	25	1633	10	39
294.25	1087[3]	10	24[4]	1598[3]	10	38[4]
303.25	1006	5[2]	23	1510	5[2]	37
311.25	1027	5[2]	22	1538	5[2]	36
319.25	1048	5[2]	21	1566	5[2]	35
327.25	1068	5[2]	20	1593	5[2]	34
335.25	1087	5[2]	19	1619	5[2]	33
343.25	1205	10	18	1744	10	32
351.25	1185	19	17	1731	19	31
359.25	1157	5[2]	16	1710	5[2]	30
367.25	1177	5[2]	15	1737	5[2]	29
375.25	1191	5[2]	23[12]	1758	5[2]	28
383.25	1205	5[2]	24[13]	1779	5[2]	27
391.25	1217	5[2]	25[14]	1798	5[2]	26
399.25	1265	5[2]	28[11]	1853	5[2]	28[11]
407.25	1283	29	10	1878	29	24
415.25	1260	5[2]	9	1862	5[2]	23
423.25	1273	5[2]	8	1882	5[2]	22
431.25	1281	5[2]	23[12]	1897	5[2]	23[12]
439.25	1288	5[2]	22[13]	1911	5[2]	22[13]
447.25	1294	5[2]	21[14]	1924	5[2]	21[14]
455.25	1303	5[2]	24[11]	1940	5[2]	24[11]

System CTB and CSO for 88 and 102 PAL B/G Channels

Visual Carrier Freq. (MHz)	550 MHz 88 Channels			650 MHz 102 Channels		
	CTB	CSO –0.75	CSO +0.75	CTB	CSO –0.75	CSO +0.75
463.25	1327	23	4	1971	23	17
471.25	1309	4	6^{11}	1960	5^{2}	16
479.25	1316	6	6^{11}	1974	6	15
487.25	1317	6	17^{12}	1982	6	17^{12}
495.25	1318	6	16^{13}	1990	6	13
503.25	1317	6	15^{14}	1996	6	15^{14}
511.25	1317	6	18^{11}	2002	6	18^{11}
519.25	1316	17	6^{11}	2010	17	10
527.25	1310	6	8^{11}	2010	6	9
535.25	1309	8	8^{11}	2015	8	8
543.25	1305	8	11^{12}	2017	8	11^{12}
551.25	1299	8	10^{13}	2017	8	10^{13}
559.25	1294	8	9^{14}	2018	8	9^{14}
567.25	1286	8	12^{11}	2016	8	12^{11}
575.25	1275	11	8^{11}	2015	11	8^{11}
583.25	1263	8	10^{11}	2011	8	10^{11}
591.25	1255	10	10^{11}	2008	10	10^{11}
599.25	1244	10	10^{11}	2002	10	10^{11}
607.25	1234	11	10^{11}	1997	11	10^{11}
615.25	1221	12	10^{11}	1989	12	10^{11}
623.25	1209	13	10^{11}	1983	13	10^{11}
631.25	1190	14	10^{11}	1971	14	10^{11}
639.25	1166	15	10^{11}	1963	15	10^{11}
647.25	1150	16	10^{11}	1952	16	10^{11}
655.25	1135	17	10^{11}	1942	17	10^{11}
663.25	1117	18	10^{11}	1929	18	10^{11}
671.25	1100	19	10^{11}	1917	19	10^{11}
679.25	1080	20	10^{11}	1902	20	10^{11}
687.25	1057	21	10^{11}	1884	21	10^{11}
695.25	1017	22	10^{11}	1865	22	10^{11}
703.25	997	23	10^{11}	1850	23	10^{11}
711.25	974	24	10^{11}	1832	24	10^{11}
719.25	952	25	10^{11}	1815	25	10^{11}
727.25	927	26	10^{11}	1795	26	10^{11}
735.25	903	27	10^{11}	1776	27	10^{11}
743.25	878	28	10^{11}	1750	28	10^{11}
751.25	–	–	–	1719	29	10^{11}

System CTB and CSO for 88 and 102 PAL B/G Channels

Visual Carrier Freq. (MHz)	550MHz 88 Channels			650MHz 102 Channels		
	CTB	CSO –0.75	CSO +0.75	CTB	CSO –0.75	CSO +0.75
759.25	–	–	–	1696	30	10[11]
767.25	–	–	–	1674	31	10[11]
775.25	–	–	–	1649	32	10[11]
783.25	–	–	–	1625	33	10[11]
791.25	–	–	–	1598	34	10[11]
799.25	–	–	–	1568	35	10[11]
807.25	–	–	–	1521	36	10[11]
815.25	–	–	–	1494	37	10[11]
823.25	–	–	–	1464	38	10[11]
831.25	–	–	–	1435	39	10[11]
839.25	–	–	–	1403	40	10[11]
847.25	–	–	–	1372	41	10[11]
855.25	–	–	–	1340	42	10[11]

1. Maximum CTB occurs at –1.0MHz.
2. Maximum beats are located at –0.25MHz from carrier.
3. Maximum CTB occurs at +1.0MHz.
4. Maximum beats are located at+1.75MHz from carrier.
5. Maximum CTB occurs at +2.0MHz.
6. Maximum beats are located at+2.75MHz from carrier.
7. Maximum CTB occurs at +3.0MHz.
8. Maximum beats are located at+3.75MHz from carrier.
9. Maximum CTB occurs at +4.0MHz.
10. Maximum beats are located at –1.25MHz from carrier.
11. Maximum beats are located at +0.25MHz from carrier.
12. Maximum beats are located at +3.25MHz from carrier.
13. Maximum beats are located at +2.25MHz from carrier.
14. Maximum beats are located at +1.25MHz from carrier.

3.5 Derating Performance

3.5.1 With Cascaded Amplifiers of Similar Distortion

Use the following procedure to determine the performance of an amplifier cascade when the amplifiers have similar distortion characteristics. All values are in dB.

***Note**: CTB and XM degrade on a voltage basis. CNR and CSO degrade on a power basis.*

➤ ***To determine the performance of an amplifier cascade***

1. Determine the number of amplifiers in cascade.
2. Refer to Section 3.5.2, *Derating Factor for Amplifiers with Similar Distortion*. Find the Voltage and Power derating factors for this number of cascaded amplifiers.
3. Subtract the Power derating factor from the CNR and CSO distortion parameters and the Voltage derating factor from the CTB and XM parameters.

Example: Find the distortion performance of eight amplifiers in cascade, given the amplifier parameters CTB = 102.0, CSO = 90.5, XM = 97.0, and CNR = 61.0, all in dB.

Referring to the Section 3.5.2 Derating Factor table, we find the following derating factors for eight amplifiers in cascade:

Power: 9.03

Voltage: 18.06

Subtracting the appropriate factor from each parameter results in the following values:

Output Level/ Distortion	Performance for One Amplifier	Derating Factor	Performance for Eight Amplifiers
CTB	102.0	–18.06	= 83.9
CSO	90.5	–9.03	= 81.5
XM	97.0	–18.06	= 78.9
CNR	61.0	–9.03	= 52.0

3.5.2 Derating Factor for Amplifiers with Similar Distortion

Use this chart with the procedure of Section 3.5 to find the distortion performance of a cascade of similar amplifiers.

All values are in dB.

# of Amps	Power (CNR/CSO)	Voltage (CTB/XM)	# of Amps	Power (CNR/CSO)	Voltage (CTB/XM)
1	0.00	0.00	26	14.15	28.30
2	3.01	6.02	27	14.31	28.63
3	4.77	9.54	28	14.47	28.94
4	6.02	12.04	29	14.62	29.25
5	6.99	13.98	30	14.77	29.54
6	7.78	15.56	31	14.91	29.83
7	8.45	16.90	32	15.05	30.10
8	9.03	18.06	33	15.19	30.37
9	9.54	19.08	34	15.31	30.63
10	10.00	20.00	35	15.44	30.88
11	10.41	20.83	36	15.56	31.13
12	10.79	21.58	37	15.68	31.36
13	11.14	22.28	38	15.80	31.60
14	11.46	22.92	39	15.91	31.82
15	11.76	23.52	40	16.02	32.04
16	12.04	24.08	41	16.13	32.26
17	12.30	24.61	42	16.23	32.46
18	12.55	25.11	43	16.33	32.67
19	12.79	25.58	44	16.43	32.87
20	13.01	26.02	45	16.53	33.06
21	13.22	26.44	46	16.63	33.26
22	13.42	26.85	47	16.72	33.44
23	13.62	27.23	48	16.81	33.62
24	13.80	27.60	49	16.90	33.80
25	13.98	27.96	50	16.99	33.98

3.5.3 With Cascaded Amplifiers of Dissimilar Distortion

Use the following procedure to find the performance of two amplifiers with different CNR, CSO, and/or CTB values. The performance of a cascade of amplifiers combined with another amplifier, or cascade of amplifiers, may be determined by using previously determined distortion parameters.

➤ ***To find the performance of cascaded amplifiers of dissimilar distortion***

1. Find the difference between the same distortion parameter for two different amplifiers (*Example: CNR parameter*).
2. Determine the derating factor:
   - Use Section 3.6, *Voltage Addition Chart*, to find the derating factor for CTB and XM.
   - Use Section 3.7, *Power Addition Chart*, to find the derating factor for CNR and CSO.
3. Separate the difference value into two portions, the integer and decimal portions. *(Example: For a difference of 15.4, the integer portion = 15, the decimal portion = .4)*
4. In the appropriate table, find the required derating factor in the row of the integer portion of the difference, and in the column of the decimal portion. *(Example: for 15.4 in the Voltage Addition Chart, the derating factor is 1.36)*
5. Subtract the derating factor from the *lower* value parameter to find the performance of the two amplifiers in cascade.
6. Repeat Steps 1 to 5 for each parameter using the Power Addition Chart for CNR and CSO.

Derating Factor and Combined Performance in the table below were determined following the above procedure from the given Trunk and Bridger parameters.

	Trunk	Bridger	Derating Factor	Cascaded Performance
CSO	73.0	70.0	4.65	65.3
CNR	52.0	69.5	.14	51.9
CTB	78.9	64.0	1.44	62.6

3.6 Voltage Addition Chart

Use this chart to find the cascaded CTB and XM values for cascaded amplifiers. CTB and XM are voltage functions. The power ratio of two voltages is given by $20\log(V_1/V_2)$. All values are in dB.

Diff.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	6.02	5.97	5.92	5.87	5.82	5.77	5.73	5.68	5.63	5.58
1	5.53	5.49	5.44	5.39	5.35	5.30	5.26	5.21	5.17	5.12
2	5.08	5.03	4.99	4.95	4.90	4.86	4.82	4.78	4.73	4.69
3	4.65	4.61	4.57	4.53	4.49	4.45	4.41	4.37	4.33	4.29
4	4.25	4.21	4.17	4.13	4.10	4.06	4.02	3.98	3.95	3.91
5	3.88	3.84	3.80	3.77	3.73	3.70	3.66	3.63	3.60	3.56
6	3.53	3.50	3.46	3.43	3.40	3.36	3.33	3.30	3.27	3.24
7	3.21	3.18	3.15	3.12	3.09	3.06	3.03	3.00	2.97	2.94
8	2.91	2.88	2.85	2.83	2.80	2.77	2.74	2.72	2.69	2.66
9	2.64	2.61	2.59	2.56	2.53	2.51	2.48	2.46	2.44	2.41
10	2.39	2.36	2.34	2.32	2.29	2.27	2.25	2.22	2.20	2.18
11	2.16	2.13	2.11	2.09	2.07	2.05	2.03	2.01	1.99	1.97
12	1.95	1.93	1.91	1.89	1.87	1.85	1.83	1.81	1.79	1.77
13	1.75	1.74	1.72	1.70	1.68	1.67	1.65	1.63	1.61	1.60
14	1.58	1.56	1.55	1.53	1.51	1.50	1.48	1.47	1.45	1.44
15	1.42	1.41	1.39	1.38	1.36	1.35	1.33	1.32	1.31	1.29
16	1.28	1.26	1.25	1.24	1.22	1.21	1.20	1.19	1.17	1.16
17	1.15	1.14	1.12	1.11	1.10	1.09	1.08	1.06	1.05	1.04
18	1.03	1.02	1.01	1.00	0.99	0.98	0.96	0.95	0.94	0.93
19	0.92	0.91	0.90	0.89	0.88	0.87	0.86	0.86	0.85	0.84
20	0.83	0.82	0.81	0.80	0.79	0.78	0.77	0.77	0.76	0.75
21	0.74	0.73	0.73	0.72	0.71	0.70	0.69	0.69	0.68	0.67
22	0.66	0.66	0.65	0.64	0.64	0.63	0.62	0.61	0.61	0.60
23	0.59	0.59	0.58	0.57	0.57	0.56	0.56	0.55	0.54	0.54
24	0.53	0.53	0.52	0.51	0.51	0.50	0.50	0.49	0.49	0.48
25	0.48	0.47	0.46	0.46	0.45	0.45	0.44	0.44	0.43	0.43

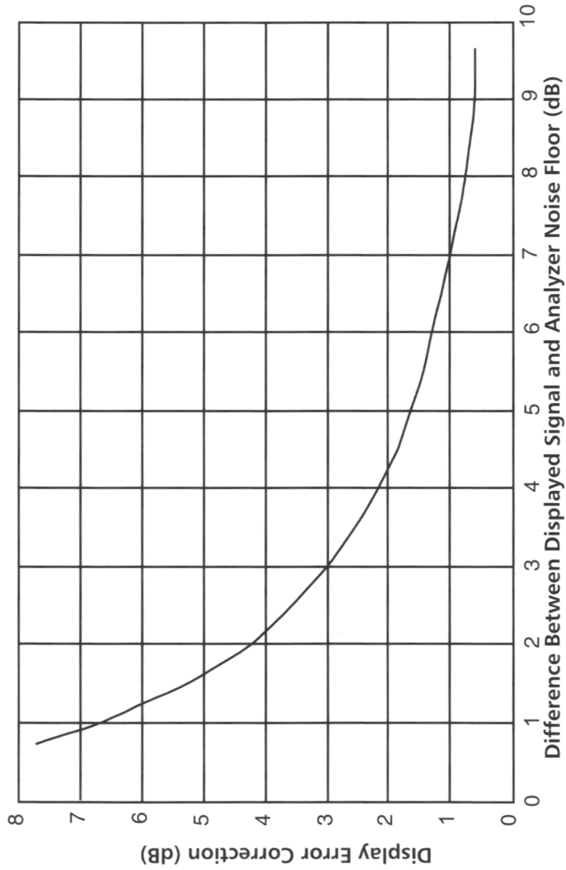
3.7 Power Addition Chart

Use this chart to find the cascaded CNR and CSO values for cascaded amplifiers. CNR and CSO are power functions. The ratio of two powers is expressed as $10\log(P_1/P_2)$. All values are in dB.

Diff.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	3.01	2.96	2.91	2.86	2.81	2.77	2.72	2.67	2.63	2.58
1	2.54	2.50	2.45	2.41	2.37	2.32	2.28	2.24	2.20	2.16
2	2.12	2.09	2.05	2.01	1.97	1.94	1.90	1.87	1.83	1.80
3	1.76	1.73	1.70	1.67	1.63	1.60	1.57	1.54	1.51	1.48
4	1.46	1.43	1.40	1.37	1.35	1.32	1.29	1.27	1.24	1.22
5	1.19	1.17	1.15	1.12	1.10	1.08	1.06	1.04	1.01	0.99
6	0.97	0.95	0.93	0.91	0.90	0.88	0.86	0.84	0.82	0.81
7	0.79	0.77	0.76	0.74	0.73	0.71	0.70	0.68	0.67	0.65
8	0.64	0.63	0.61	0.60	0.59	0.57	0.56	0.55	0.54	0.53
9	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42
10	0.41	0.40	0.40	0.39	0.38	0.37	0.36	0.35	0.35	0.34
11	0.33	0.32	0.32	0.31	0.30	0.30	0.29	0.28	0.28	0.27
12	0.27	0.26	0.25	0.25	0.24	0.24	0.23	0.23	0.22	0.22
13	0.21	0.21	0.20	0.20	0.19	0.19	0.19	0.18	0.18	0.17
14	0.17	0.17	0.16	0.16	0.15	0.15	0.15	0.14	0.14	0.14
15	0.14	0.13	0.13	0.13	0.12	0.12	0.12	0.12	0.11	0.11
16	0.11	0.11	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09
17	0.09	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07
18	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06
19	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04
20	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
21	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
22	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02
23	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
24	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01
25	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

3.8 Spectrum Analyzer Error Correction Chart

Use this chart to correct spectrum analyzer signal measurement when the signal is within 10 dB of the instrument noise floor (from the spectrum analyzer data sheet). Add the Display Error Correction to the measured value to obtain the correct value.



3.9 dBmV/Hz Bandwidth Conversion

Power per Hz is a measure of the total power within a given bandwidth (such as 1 Hz, 1 MHz, 6 MHz). This is actually a power density, or loading. To convert a known total power in one bandwidth to the total power in another bandwidth, use the following equation:

$$P_2 = P_1 + 10\log\frac{x_2}{x_1}$$

where:

P2 = Total power in new bandwidth

P1 = Total power in current bandwidth

$\mathbf{x_2}$ = New bandwidth

$\mathbf{x_1}$ = Current bandwidth

Examples:

1. If a power is specified as –50 dBmV/Hz, then what is the power in a 6 MHz channel?

   $\mathbf{x_1}$ = 1 Hz, $\mathbf{x_2}$ = 6 MHz, **P1** = –50 dBmV

$$P_2 = P_1 + 10\log\frac{6 \times 10^6}{1}$$
$$P_2 = -50 + 10(6.78)$$
$$P_2 = 17.8\,\text{dBmV}$$

2. If the noise power in a 6 MHz channel is 2.5 dBmV, then what is the total noise power in the 4 MHz video band?

   $\mathbf{x_1}$ = 6 MHz, $\mathbf{x_2}$ = 4 MHz, **P1** = 2.5 dBmV

$$P_2 = P_1 + 10\log\frac{4 \times 10^6}{6 \times 10^6}$$
$$P_2 = 2.5 + 10(-0.176)$$
$$P_2 = 0.74\,\text{dBmV}$$

3.10 Return Loss, Reflection, and Standing Waves

Return loss is the most common measure of signal reflections (VSWR).

$$\textbf{Return Loss (in dB)} = 30\log\frac{1}{\Gamma}$$

The reflection coefficient is gamma (Γ), P_r = reflected wave power, P_i = incident wave power.

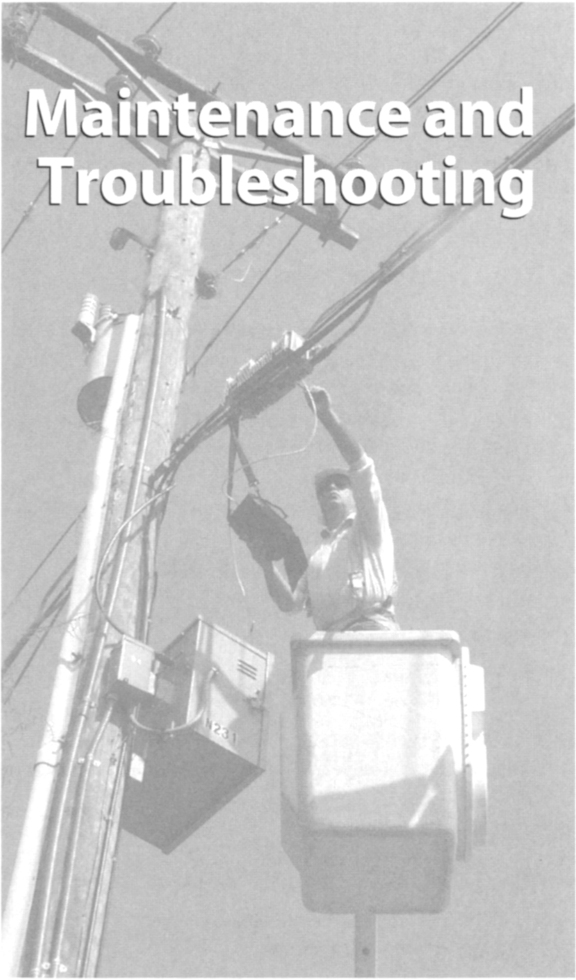
$$\Gamma = \sqrt{\frac{P_r}{P_i}}$$

$$\textbf{VSWR} = \frac{1+\Gamma}{1-\Gamma}$$

Return Loss dB Down	Reflection Coefficient (%)	VSWR	Return Loss dB Down	Reflection Coefficient (%)	VSWR
0.0	100.0	–	8.0	39.8	2.32
0.5	94.4	34.7	8.5	37.6	2.21
1.0	89.1	17.3	9.0	35.5	2.10
1.5	84.1	11.6	9.5	33.5	2.01
2.0	79.4	8.71	10.0	31.6	1.92
2.5	75.0	7.00	10.5	29.9	1.85
3.0	70.8	5.85	11.0	28.2	1.79
3.5	66.8	5.02	11.5	26.6	1.72
4.0	63.1	4.42	12.0	25.1	1.67
4.5	59.6	3.95	12.5	23.7	1.62
5.0	56.2	3.57	13.0	22.4	1.58
5.5	53.1	3.26	13.5	21.1	1.53
6.0	50.1	3.01	14.0	20.0	1.50
6.5	47.3	2.80	14.5	18.8	1.46
7.0	44.7	2.62	15.0	17.8	1.43
7.5	42.2	2.46	15.5	16.8	1.40

Return Loss dB Down	Reflection Coefficient (%)	VSWR
16.0	15.9	1.38
16.5	15.0	1.35
17.0	14.1	1.33
17.5	13.3	1.31
18.0	12.6	1.29
18.5	11.9	1.27
19.0	11.2	1.25
19.5	10.6	1.233
20.0	10.0	1.222
20.5	9.44	1.208
21.0	8.91	1.196
21.5	8.41	1.184
22.0	7.94	1.172
22.5	7.50	1.162
23.0	7.08	1.152
23.5	6.68	1.143
24.0	6.31	1.135
24.5	5.96	1.127
25.0	5.62	1.119
25.5	5.31	1.112
26.0	5.01	1.105
26.5	4.73	1.099
27.0	4.47	1.094
27.5	4.22	1.088
28.0	3.98	1.083
28.5	3.76	1.078
29.0	3.55	1.074
29.5	3.35	1.069
30.0	3.16	1.065
30.5	2.99	1.062

Maintenance and Troubleshooting



4.1 Cumulative Leakage Index Calculation (CLI)

Cumulative Leakage Index (CLI), also referred to as a "figure of merit" measurement, is a method for assessing the signal leakage integrity of an RF network. A quarterly signal leakage monitoring program, noting leaks of $\geq$ 20 μv/m at a distance of 3 meters, must be maintained. The cable operator can demonstrate compliance with the FCC cumulative signal leakage standard by calculating the last quarter (calendar year) data with either the I_{3000} method or with the $I_{infinity}$ method.

4.1.1 I_{3000} Method

$$10 \log I_{3000} \leq -7$$

➤ ***To calculate the I_{3000} method use the following procedure***

(**R** in Step 1 is the slant height distance from the leakage source to an imaginary spot 3000 meters above the center of the system).

1. Multiply the value of each leak that is $\geq$ 50 μv/m by itself and divide by the square of the slant height R.
2. Add all these leaks together.
3. If measuring less than the entire system, divide the sum in Step 2 by the fraction of the system that was measured.
4. Find the logarithm of the number in Step 3.
5. Multiply that number by 10.
6. The resulting CLI test number should be $\leq$ –7.

4.1.2 $I_{infinity}$ Method

$$10 \log I_{\infty} \leq 64$$

➤ ***To calculate the $I_{infinity}$ method use the following procedure***

1. Multiply the value of each leak that is 50 μV/m or greater by itself.
2. Add all these leaks together.
3. If measuring less than the entire system, divide the sum in Step 2 by the fraction of the system that was measured.
4. Find the logarithm of the number in Step 3.
5. Multiply that number by 10.
6. A result of $\leq$ 64 is in compliance with FCC standards.

4.2 Maximum Leakage Field Strength Levels

The following table states, for the frequencies shown, the measured dBmV leakage levels which correspond to field strengths of 20 and 50μV/m.

Ch #	Visual Carrier	20μV/ m (dBmV)	50μV/ m (dBmV)	Ch #	Visual Carrier	20μV/ m (dBmV)	50μV/ m (dBmV)
14	121.2625	-42.10	-34.14	38	307.2625	-50.17	-42.22
15	127.2625	-42.52	-34.56	39	313.2625	-50.34	-42.38
16	133.2625	-42.92	-34.96	40	319.2625	-50.51	-42.55
25	229.2625	-47.63	-39.67	41	325.2625	-50.67	-42.71
26	235.2625	-47.85	-39.90	42	331.2625	-50.83	-42.87
27	241.2625	-48.07	-40.11	43	337.2625	-50.98	-43.02
28	247.2625	-48.29	-40.33	44	343.2625	-51.14	-43.18
29	253.2625	-48.50	-40.54	45	349.2625	-51.29	-43.33
30	259.2625	-48.70	-40.74	46	355.2625	-51.43	-43.48
31	265.2625	-48.90	-40.94	47	361.2625	-51.58	-43.62
32	271.2625	-49.09	-41.13	48	367.2625	-51.72	-43.76
33	277.2625	-49.28	-41.32	49	373.2625	-51.86	-43.91
34	283.2625	-49.47	-41.51	50	379.2625	-52.00	-44.04
35	289.2625	-49.65	-41.69	51	385.2625	-52.14	-44.18
36	295.2625	-49.83	-41.87	52	391.2625	-52.27	-44.31
37	301.2625	-50.00	-42.04	53	397.2625	-52.41	-44.45

Maximum leakage level may also be calculated from:

$$L = 20 \log \left[\frac{E}{21f} \right]$$

where:

L = Maximum leakage level in dBmV

E = Voltage in μV/m

f = Visual carrier frequency in MHz

4.3 Leakage Measurement at Different Distances

The equation for correlating signal levels from a known distance (y) to 3 meters (10 feet) is:

µV/m at 10 ft = (µV/m at y ft) x (y/10)

Example:

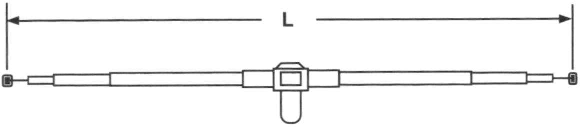
µV/m at 10 ft = (12.5 µV/m at 80 ft) x (80/10)
µV/m at 10 ft = 12.5 x 8
µV/m at 10 ft = 100

Use the following table to convert leakage measurements made at the distances listed to µV/m if measured 10 feet from the source.

µV/m at	Equivalent µV/m when measured at:			
10 ft	**15 ft**	**25 ft**	**40 ft**	**80 ft**
20	13.33	8	5	2.50
50	33.33	20	12.5	6.25
100	66.66	40	25	12.5
200	133.33	80	50	25
300	200	120	75	37.5
400	266	160	100	50
600	400	240	150	75
800	533.33	320	200	100
1200	800	480	300	150
1500	1000	600	375	187.5

4.4 Dipole Antenna Equations

A typical half-wave dipole, or Hertz, antenna is illustrated below. The radiation/reception pattern of a dipole antenna is perpendicular to the axis of the antenna. In directions parallel to the axis, both reception and radiation by this antenna are ineffective. Always orient the dipole to be broadside to a signal source.



The ideal length, **L**, of a half-wave dipole antenna is given by:

$$L_{\text{feet}} = \frac{468}{\text{Frequency in MHz}}$$

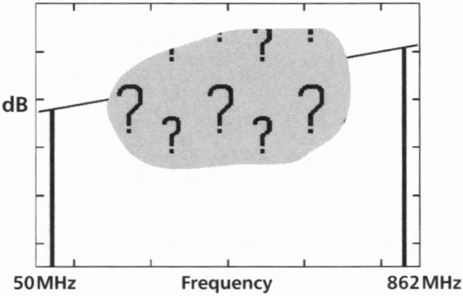
$$L_{\text{meters}} = \frac{143}{\text{Frequency in MHz}}$$

4.5 Sweep vs. Balance

Both sweep and rough balance testing provide information about broadband signals; however, the information is different in form and purpose.

Rough Balance testing is limited to measuring one signal level at a time with a Signal Level Meter (SLM) at a few different frequencies within the system bandwidth. Ideally, these frequencies are the highest and lowest in the band, but may be any convenient frequencies. One is considered the "high-balancing carrier," another the "low-balancing carrier."

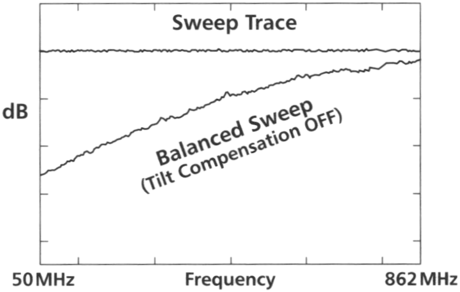
When measuring only a few carriers, you cannot see the entire bandwidth and problems may remain undetected. (See figure below.)



Bandedge Balancing

Sweep testing, typically performed for certification or troubleshooting, is a much more sophisticated function that requires a synchronized sweep transmitter and sweep receiver. The transmitter sends, and the receiver receives, very quick pulses on each unused frequency in the band. The receiver has a screen that displays a graph trace representing the signal pulses across the entire bandwidth of the system. The shape of this graph trace is known as the system "sweep response." Analysis of irregularities in the signature response can be a powerful troubleshooting tool for the knowledgeable and experienced technician.

The difference between the levels at the system highest and lowest frequencies is the "tilt." The balanced sweep with its tilt is shown on the figure below.



Clean Sweep Trace

4.5.1 System Sweep

Sweep testing requires a field strength meter (FSM) with sweep receiver capabilities in the tested passband. The trace this meter displays is a graphical representation of the RF output level at all frequencies in the passband. It is the "sweep response" of the device or system being tested. With knowledge and experience, this signature provides a useful tool for identifying problems in a CATV network.

Contributing factors to a system's signature include:

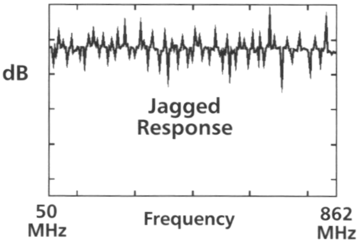
- The signature of the individual amplifiers used in the system (Amplifiers of the same type have similar signatures which tend to build up)
- Passives, including couplers, splitters, taps, cable and connectors, pads and equalizers
- Construction practices.

The key to sweep testing and troubleshooting lies in an understanding of the difference between normal RF cascade sweep response and abnormal peak-to-valley response. Each problem will exhibit an identifiable sweep display that, through experience, will be apparent to the technician.

When assessing the significance of signature irregularities, you can tolerate more irregularity at the end of a cascade, after signatures are built up, than at the beginning of a cascade.

Some common system response problems and their typical causes are:

Jagged Response—Positive and negative spikes, closely spaced across the band, but sometimes in specific bands with smaller amplitude—often very erratic.

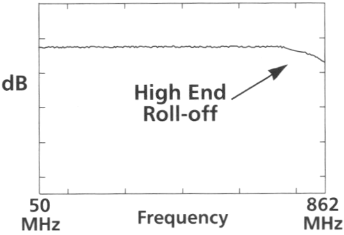


Causes: Most often caused by water damage and/or corrosion, often found in older underground cable.

Roll-off—Frequency response level drop-off near the upper or lower bandedges.

Causes:

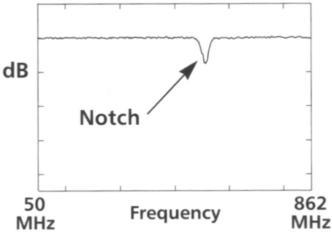
- Loose connectors or center-seizure screws
- Loose modules
- Amplifier misalignment
- Diplex filter problems
- Improper splicing such as scraping of the center conductor
- Taps, passives, or plug-in accessories in the system designed for a lower passband. (Example: 750MHz EQ in an 862MHz system).



Notch—A sharp, often deep, negative dip.

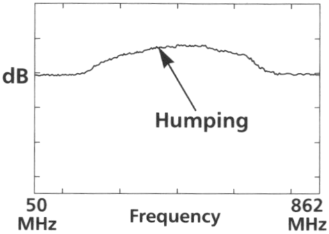
Causes:

- Loose connectors
- Tap/coupler faceplates or amplifier modules
- Internal RF grounding problems in the amplifier.

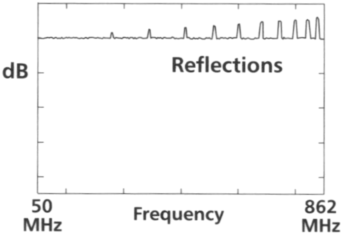


Humping—A signal build-up of the midband.

Causes: Over-equalizing amplifiers in the affected cascade, especially if equalization has been used to correct roll-off.



Reflections—Standing waves. Stable symmetrical peaks and valleys in the response, typically across the entire band but may appear only in the higher frequency region.



Causes: An impedance mismatch—a point in the signal path with an impedance of other than 75 Ω. Reflections are most common in amplifiers with bi-directional testpoints.

Bi-directional testpoints are always resistive and are very useful when troubleshooting sweep response issues and fault locations. Standing waves, or reflections, in the forward sweep can be used to determine the distance **D** to a fault at the output of an amplifier with the formula:

$$\mathbf{D = 492(V_P/F)}$$

where:

D = Distance to the fault (feet)

492 = A constant factor (use **149** for distance in meters)

V_P = Velocity of propagation of cable (% speed of light, 87 typical)

F = Frequency width (MHz)—the bandwidth spanned by one cycle of the standing wave

***Note*: F** *is often best measured by determining the frequency width of several standing waves, then dividing by the number of standing waves you measured.*

4.6 Troubleshooting

There is no substitute for experience in troubleshooting CATV systems. However, some tips, reminders, and general information is provided in this section.

4.6.1 Required Equipment

- Field strength meter (FSM)
- True RMS voltmeter
- Standard technician hand tools
- Optical power meter (optional)
- Spare supplies such as, plug-in accessories, module passives, connectors
- System maps

4.6.2 Reminders

For each amplifier, verify the following:

- The amplifier has proper input voltage (60/90VAC)
- Raw DC
- B+ voltages
- Ripple
- ALC is on and verified
- All required accessories are properly installed
- Unused ports, ends of cables, and split points have 75Ω termination.
- Check for visible problems such as, water damage/ corrosion, burnt components, blown fuses, loose or missing parts
- If using a test TV, the input testpoint to an amplifier will always display snowy pictures due to the low signal.

4.6.3 Service Outage Troubleshooting—Forward

System outages demand fast response and repair times. Pinpointing a problem is made easier with good information on the outage. Information from the dispatcher or office as to exactly which areas or specific addresses are affected, and those which are not, can often enable you to pinpoint the problem to a specific power supply or amplifier without getting out of the truck.

While troubleshooting an outage, look past minor system level deviations. Do not waste time adjusting levels that are within a couple of dB while customers are without service (no picture).

In most cases, the "divide and conquer" rule works best. Establish the most distant point from the headend at which signal is verified and start midway between this point and the affected subscribers. Work forward or backward as your information dictates, always going to the middle of the identified problem cascade.

At each amplifier:

Check RF input levels at an amplifier, or the optical receiver input power at a node.

If the input is *bad*:

- Verify optical signal with a power meter.
- If there is no optical signal, the problem is either with the fiber or at the headend or hub.
- If the optical input level is correct, it is possible that there is no RF on the light. The problem is either the node optical receiver or the headend/hub transmitter.

If the input is *good*, check the RF output.

- If the RF output is *bad*, test the AC and B+ voltages.
  - If no RF, check fuses, the system power supply, or the amplifier that feeds AC to the amplifier being tested.
  - If AC OK but not B+, check main fuse and the 24V power supply.

    - If AC and B+ are OK, replace the amplifier RF module. (Remove all plug-ins from the module being removed and install them in the replacement amplifier.)
- If RF is *good*, move downstream to the midpoint of the remaining problem cascade, repeating the above tests.

4.6.4 Service Outage Troubleshooting—Return

Return path noise and ingress can result from:

- stationary impairments
  - thermal noise
  - intermodulation distortion
  - frequency response problems
- transient impairments
  - RF ingress
  - impulse noise
  - signal clipping
- multiplicative impairments
  - transient hum modulation
  - intermittent connections

Reducing noise and ingress in the return path should be part of a long-term maintenance plan; however, follow these procedures to troubleshoot noise and ingress in the return path.

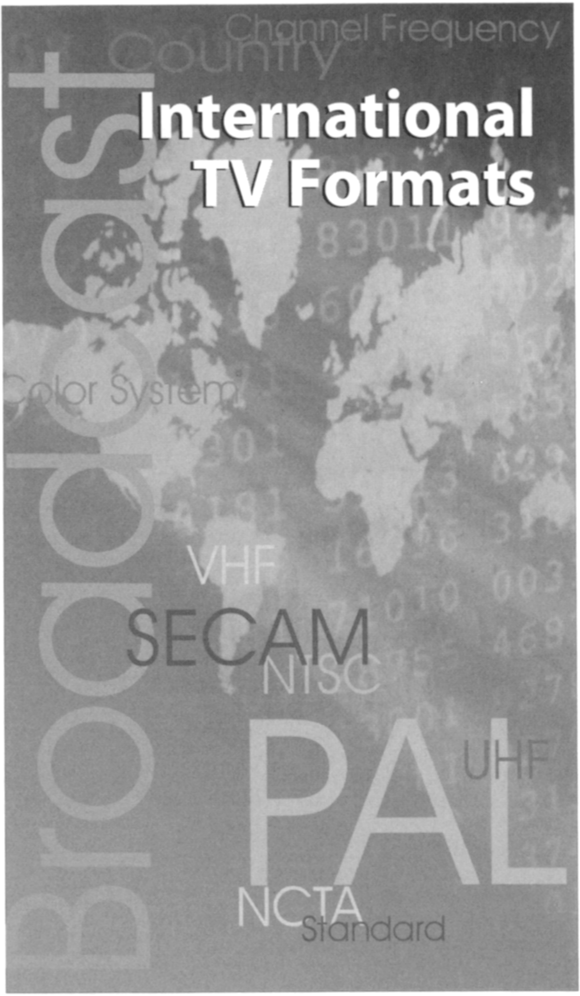
1. Systematically check the signal level at the Return Path Receiver testpoints in the headend or hub until the problem node is determined.
2. Once the problem node is located, insert a pad (6dB, for example) into the reverse pad location for each port of the node while monitoring the signal on a spectrum analyzer to determine on which cascade the problem lies. (The signal on the problem port/cascade will drop by 6dB.)

3. In most cases, the "divide and conquer" rule works best. Establish the most distant point from the headend at which the signal is verified and start midway between this point and the affected subscribers. Work forward or backward as your information dictates, always going to the middle of the identified problem cascade (testing halfway through the plant, then dividing in half again, etc.) determine the problem amplifier.
4. Once the problem amplifier is isolated, continue testing to locate the suspect port. Determine if the noise or ingress is resulting from:
    - loose, corroded, or improperly installed connectors
    - damaged cabling
    - loose or improperly torqued amplifier lids
    - loose passive device faceplates
    - or loose or corroded F-port teminators.
    - Poorly shielded consumer devices may also be causing the problem.

First, repair all obvious hardware problems, including the customer drop. It may be necessary to contact the customer and inform them of the problem as they may be contributing to it. It may be necessary to use filters at the drop.

***Note**: It may be necessary to continue to isolate the problem to a specific tap port by disconnecting individual subscriber drops from the tap until the noise/interference disappears.*

International TV Formats


Channel Frequency
Country
Broadcast
Color System
VHF
SECAM
NTSC
PAL
UHF
NCTA
Standard

5.1 International Channel Standards

Country	Color System	Broadcast Standard		Channel Freq.	Std. Voltage and Cycles (Hz)	
		VHF	UHF			
Argentina	PAL	N	N	NCTA	220	50
Australia	PAL	B	G	Australian	240	50
Austria	PAL	B	G	West Euro	230	50
Bahamas	NTSC	M	—	NCTA	120	60
Belgium	PAL	B	H	West Euro	230	50
Bermuda	NTSC	M	—	NCTA	120/240	60
Bolivia	NTSC	M	N	NCTA	110/220	50
Brazil	PAL	M	M	NCTA	110/220	60
Canada	NTSC	M	M	NCTA	120	60
Chile	NTSC	M	M	NCTA	220	50
China	PAL	D	—	Chinese	220	50
Colombia	NTSC	M	M	NCTA	110	60
Costa Rica	NTSC	M	M	NCTA	120	60
Denmark	PAL	B	G	West Euro	220	50
Ecuador	NTSC	M	M	NCTA	120/220	60
Egypt	SECAM/PAL	B	G	West Euro	220	50
Finland	PAL	B	G	West Euro	220	50
France	SECAM	L	L	French	220	50
Germany	SECAM/PAL	B	G	West Euro	220	50
Greece	SECAM/PAL	B	G	West Euro	220	50
Hong Kong	PAL	—	I	West Euro	220	50
Hungary	SECAM/PAL	D	K	East Euro	220	50
India	PAL	B	—	West Euro	240	50
Indonesia	PAL	B	G	West Euro	110/220	50
Iran	SECAM	B	G	West Euro	220	50
Iraq	SECAM	B	—	West Euro	220	50
Ireland	PAL	I	I	Irish	220	50
Israel	PAL	B	G	West Euro	220	50
Italy	PAL	B	G	Italian	220	50
Japan	NTSC	M	M	Japanese	110	50/60
Jordan	PAL	B	G	West Euro	220	50
Korea S.	NTSC	M	M	NCTA	110	60
Kuwait	PAL	B	G	—	240	50
Malaysia	PAL	B	G	West Euro	230	50
Mexico	NTSC	M	M	NCTA	110-125	60
Morocco	SECAM	B	—	Morocco	120/220	50
Netherlands	PAL	B	G	West Euro	220	50

Country	Color System	Broadcast Standard		Channel Freq.	Std. Voltage and Cycles (Hz)	
		VHF	UHF			
New Zealand	PAL	B	G	NZ	240	50
Norway	PAL	B	G	West Euro	220	50
Panama	NTSC	M	M	NCTA	120	60
Peru	NTSC	M	M	NCTA	110/220	50/60
Philippines	NTSC	M	M	NCTA	110/220	60
Poland	SECAM/PAL	D	K	East Euro	220	50
Portugal	PAL	B	G	West Euro	220	50
Puerto Rico	NTSC	M	M	—	110	60
Romania	SECAM/PAL	D	K	East Euro	220	50
Russia	SECAM	D	K	East Euro	220	50
Saudi Arabia	SECAM/PAL	B	G	—	120/220	50
Singapore	PAL	B	G	West Euro	230	50
Spain	PAL	B	G	West Euro	120/220	50
Sweden	PAL	B	G	West Euro	220	50
Switzerland	PAL	B	G	West Euro	110/220	50
Taiwan	NTSC	M	—	—	110	60
Thailand	PAL	B	—	—	220	50
Turkey	PAL	B	G	—	110/220	50
United Arab Emirates	PAL	M	M	—	220/240	50
United Kingdom	PAL	I	I	West Euro	240	50
United States of America	NTSC	M	M	NCTA	110	60
Uruguay	PAL	N	—	NCTA	220	50
Venezuela	NTSC	M	—	NCTA	120/240	60

NTSC - National Television Systems Committee

PAL - Phase Alternating Line

SECAM - Système Électronique pour Couleur Avec Memoire

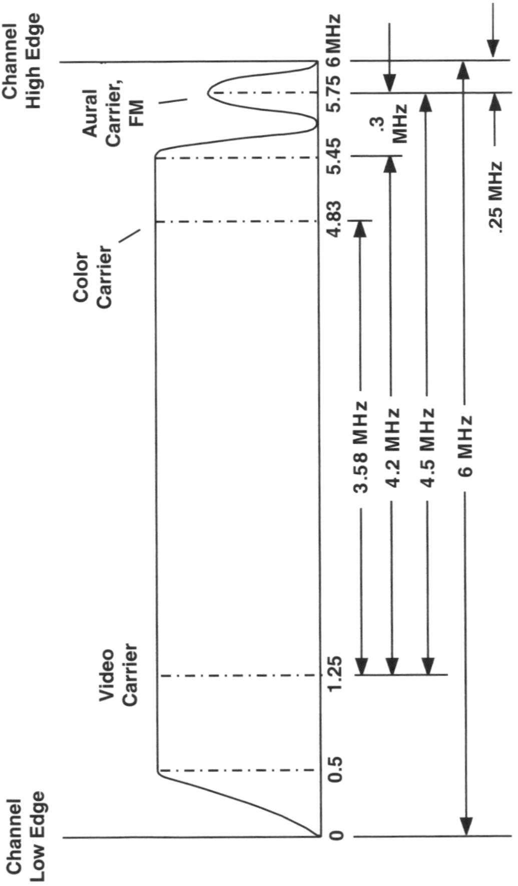
5.1.1 Broadcast Standard Letter Codes

Broadcast Standards

Broadcast Standard	Number of Lines	Channel Width (MHz)	Visual BW (MHz)	Visual/Aural Separation (MHz)	Vestigal Sidebands (MHz)	Visual Modulation	Aural MOD
A	405	5	3.0	3.5	0.75	Pos	AM
B	625	7	5.0	5.5	0.75	Neg	FM
C	625	7	5.0	5.5	0.75	Pos	AM
D	625	8	6.0	6.5	0.75	Neg	FM
G	625	8	5.0	5.5	0.75	Neg	FM
H	625	8	5.0	5.5	1.25	Neg	FM
I	625	8	5.5	6.0	1.25	Neg	FM
K	625	8	6.0	6.5	0.75	Neg	FM
K	625	8	6.0	6.5	1.25	Eng	FM
L	625	8	6.0	6.5	1.25	Pos	AM
M	525	6	4.2	4.5	0.75	Neg	FM
N	625	6	4.2	4.5	0.75	Neg	FM

5.2 Channel Formats

The NTSC channel format is shown below. Refer to “International Television Standards” on page 5-6 for parameters associated with various international channel formats.


Channel High Edge
Aural Carrier, FM
Color Carrier
Video Carrier
Channel Low Edge
6 MHz
5.75
5.45
4.83
1.25
0.5
0
.3 MHz
.25 MHz
3.58 MHz
4.2 MHz
4.5 MHz
6 MHz

Note: The aural carrier amplitude level is approximately 10 to 17 dB below the visual carrier.

International Television Standards

	NTSC	PAL B,G, H	PAL I	PAL D	PAL N	PAL M	SECAM B/H	SECAM D/K, L
Channel Width (MHz)	6	7	8	8	6	6	7	8
Video Carrier (MHz)	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Color Carrier (MHz)	4.829545	5.683618	5.683618	5.683618	4.832056	4.825611	—	—
Sound Carrier (MHz)	5.75	6.75	7.25	7.75	5.75	5.75	6.75	7.75
Video Bandwidth (MHz)	4.2	5.0	5.5	6.0	4.2	4.2	5.0	6.0
Lines/Field	525/60	625/50	625/50	625/50	625/50	525/60	625/50	625/50
Horizontal Freq. (kHz)	15.734	15.625	15.625	15.625	15.625	15.75	15.625	15.625
Vertical Freq. (Hz)	60	50	50	50	50	60	50	50

5.3 Distortion Conversions for International TV

	550 MHz	600 MHz	750 MHz	862 MHz	Units
NTSC System M					
Analog Channel Spacing	6	6	6	6	MHz
Analog Channel Loading	77	85	110	129	
PAL System B/G					
Analog Channel Spacing	b	8	8	8	MHz
Analog Channel Loading	63	69	88	102	
CTB Conversion Factor	4	4	3	1	dB
XMOD Conversion Factor	2	2	1	1	dB
CSO Conversion Factor[1]	0	0	0	0	dB
PAL System I, SECAM Systems D/K, and L					
Analog Channel Spacing	8	8	8	8	MHz
Analog Channel Loading	60	66	85	99	
CTB Conversion Factor	3	3	3	1	dB
XMOD Conversion Factor	2	2	1	1	dB
CSO Conversion Factor[2]	0	0	0	0	dB
CENELEC					
Analog Channel Loading	—	29	35	42	
CTB Conversion Factor	—	11	12	9	dB
XMOD Conversion Factor	—	8	9	9	dB
CSO Conversion Factor[2]	—	4	4	6	dB

[1] For output tilts greater than 8 dB, reduce CSO specification by 1 dB for each 1 dB tilt over 8 dB.

[2] 7 MHz below 300 MHz, 8 MHz above 300 MHz

All specifications are subject to change without notice. Measured per NCTA test methods at 70°F.

5.4 Carrier Options

Use the following carrier values with distortion conversion factors provided on page 5-7.

5.4.1 PAL B/G Video Carriers

The PAL B/G channel plan offers the following video carriers (in MHz):

48.25	196.25	319.25	455.25	591.25	727.25
55.25	203.25	327.25	463.25	599.25	735.25
62.25	210.25	335.25	471.25	607.25	743.25
69.25	217.25	343.25	479.25	615.25	751.25
76.25	224.25	351.25	487.25	623.25	759.25
112.25	231.25	359.25	495.25	631.25	767.25
119.25	238.25	367.25	503.25	639.25	775.25
126.25	245.25	375.25	511.25	647.25	783.25
133.25	252.25	383.25	519.25	655.25	791.25
140.25	259.25	391.25	527.25	663.25	799.25
147.25	266.25	399.25	535.25	671.25	807.25
154.25	273.25	407.25	543.25	679.25	815.25
161.25	280.25	415.25	551.25	687.25	823.25
168.25	287.25	423.25	559.25	695.25	831.25
175.25	294.25	431.25	567.25	703.25	839.25
182.25	303.25	439.25	575.25	711.25	847.25
189.25	311.25	447.25	583.25	719.25	855.25

5.4.2 PAL I Video Carriers

The PAL I channel plan offers the following video carriers (in MHz:)

47.25	207.25	343.25	479.25	615.25	751.25
55.25	215.25	351.25	487.25	623.25	759.25
63.25	223.25	359.25	495.25	631.25	767.25
71.25	231.25	367.25	503.25	639.25	775.25
79.25	239.25	375.25	511.25	647.25	783.25
111.25	247.25	383.25	519.25	655.25	791.25
119.25	255.25	391.25	527.25	663.25	799.25
127.25	263.25	399.25	535.25	671.25	807.25
135.25	271.25	407.25	543.25	679.25	815.25
143.25	279.25	415.25	551.25	687.25	823.25
151.25	287.25	423.25	559.25	695.25	831.25
159.25	295.25	431.25	567.25	703.25	839.25
167.25	303.25	439.25	575.25	711.25	847.25
175.25	311.25	447.25	583.25	719.25	855.25
183.25	319.25	455.25	591.25	727.25	
191.25	327.25	463.25	599.25	735.25	
199.25	335.25	471.25	607.25	743.25	

5.4.3 NTSC System M Channel Plan

The NTSC System M Channel plan offers video carriers at 55.25, 61.25, 67.25, 77.25, 83.25, 121.25, 127.25, and every 6 MHz from 127.25 MHz to 859.25 MHz.

Available frequencies follow:

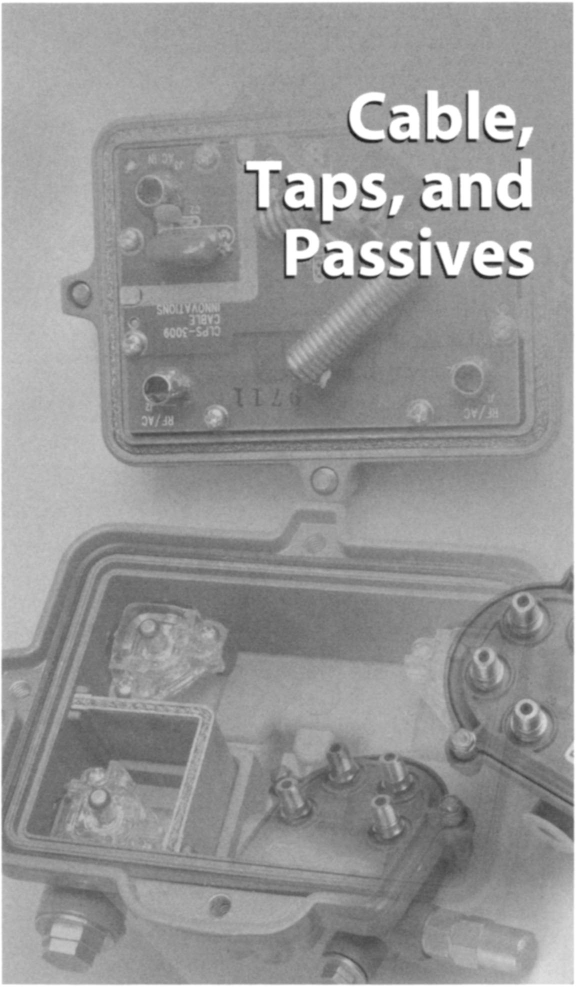
55.25	235.25	379.25	523.25	667.25	811.25
61.25	241.25	385.25	529.25	673.25	817.25
67.25	247.25	391.25	535.25	679.25	823.25
77.25	253.25	397.25	541.25	685.25	829.25
83.25	259.25	403.25	547.25	691.25	835.25
121.25	265.25	409.25	553.25	697.25	841.25
127.25	271.25	415.25	559.25	703.25	847.25
133.25	277.25	421.25	565.25	709.25	853.25
139.25	283.25	427.25	571.25	715.25	859.25
145.25	289.25	433.25	577.25	721.25	
151.25	295.25	439.25	583.25	727.25	
157.25	301.25	445.25	589.25	733.25	
163.25	307.25	451.25	595.25	739.25	
169.25	313.25	457.25	601.25	745.25	
175.25	319.25	463.25	607.25	751.25	
181.25	325.25	469.25	613.25	757.25	
187.25	331.25	475.25	619.25	763.25	
193.25	337.25	481.25	625.25	769.25	
199.25	343.25	487.25	631.25	775.25	
205.25	349.25	493.25	637.25	781.25	
211.25	355.25	499.25	643.25	787.25	
217.25	361.25	505.25	649.25	793.25	
223.25	367.25	511.25	655.25	799.25	
229.25	373.25	517.25	661.25	805.25	

5.4.4 CENELEC Video Carriers

The CENELEC test channels offers the following video carriers (in MHz:)

48.25	391.25	679.25
119.25	407.25	695.25
175.25	423.25	711.25
191.25	439.25	727.25
207.25	447.25	743.25
223.25	463.25	759.25
231.25	479.25	775.25
247.25	495.25	791.25
263.25	511.25	807.25
287.25	527.25	823.25
311.25	543.25	839.25
327.25	567.25	855.25
343.25	583.25	
359.25	599.25	
375.25	663.25	

Cable, Taps, and Passives



6.1 Basic Cable Calculations

6.1.1 Cable Loss vs. Frequency

Cable attenuation doubles as frequency quadrules. For example, if a broasband signal passes through enough cable to attenuate a 54 MHz signal by 5 dB, signals at 216 MHz are attenuated by 10 dB.

If you know the cable loss at a given frequency, you can calculate the loss at a desired frequency using the following formula:

$$L_{F_2} = L_{F_1}\sqrt{\frac{F_2}{F_1}}$$

where:

L_{F_2} = Loss at the desired frequency (dB)
L_{F_1} = Loss at the known frequency (dB)
F_2 = Desired frequency (MHz)
F_1 = Known frequency (MHz)

For specific frequencies, the result may be obtained without the formula by multiplying the dB loss at a Known Frequency (**F_1**) by the Conversion Factor in the Known Frequency row and the Desired Frequency (**F_2**) column in the table below.

Conversion Factors

Known Frequency (F_1)—MHz	220	300	450	500	550	600	650	700	750	862
220	1	1.17	1.43	1.51	1.58	1.65	1.72	1.78	1.85	1.98
300	0.86	1	1.22	1.29	1.35	1.41	1.47	1.53	1.58	1.70
450	0.70	0.82	1	1.05	1.11	1.15	1.20	1.25	1.29	1.38
500	0.66	0.77	0.95	1	1.05	1.10	1.14	1.18	1.22	1.31
550	0.63	0.74	0.90	0.95	1	1.04	1.09	1.13	1.17	1.25
600	0.61	0.71	0.87	0.91	0.96	1	1.04	1.08	1.12	1.20
650	0.58	0.68	0.83	0.88	0.92	0.96	1	1.04	1.07	1.15
700	0.56	0.65	0.80	0.85	0.89	0.93	0.96	1	1.04	1.11
750	0.54	0.63	0.77	0.82	0.86	0.89	0.93	0.97	1	1.07
862	0.51	0.59	0.72	0.76	0.80	0.83	0.87	0.90	0.93	1

Desired Frequency (F_2)—MHz

➤ *To determine cable loss at a desired frequency*

1. Using the Conversion Factors chart on page 6-2, locate the Known Frequency in the column along the left side of the chart.
2. Locate the Desired Frequency along the bottom row.
3. Multiply the Conversion Factor (the number where the Known Frequency row and Desired Frequency column intersect) by the dB loss at the Known Frequency:

$$L_{F_2} = L_{F_1} \times \textbf{Conversion Factor}$$

Example: If the loss at 750MHz is 8.0dB, then the loss at 550MHz would be 8dB x 0.86, or 6.88dB.

6.1.2 DC Loop Resistance Calculation

The DC loop resistance and RF attenuation can be calculated at temperatures other than 68°F if the nominal resistance and attenuation at 68°F is known:

$$\text{Resistance}_{\text{DC Loop@T}} = \text{Resistance}_{\text{DC Nominal}}\left[1 + \left(\frac{0.022}{10°\text{F}}\right)(\text{T} - 68°\right.$$

where:

T = ambient temperature in °F

Resistance DC Nominal = **Resistance DC Loop** $_{@\,68°\text{F}}$

also:

$$\text{RF Attenuation Loss@T} = \text{Loss at }68°\text{F}\left[1 + \left(\frac{0.01}{10°\text{F}}\right)(\text{T} - 68°\text{F})\right]$$

6.1.3 Cable Loss and Temperature Correction

***Note**: If the temperature is between 50°F and 90°F (10°C and 32°C), temperature correction is not required.*

Coaxial cable loss increases with increasing temperature and decreases with decreasing temperature. To compensate for cable loss due to temperature change, you can remember that the percentage of *change* of cable loss is measured 1% for every 10°F (5.5°C) of temperature change, or you can use the Temperature Correction Value (TCV) Chart on the following page.

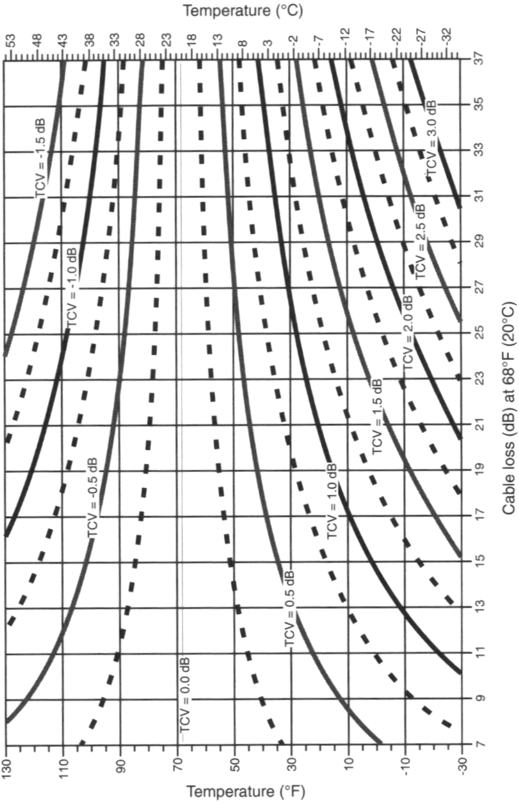
If the temperature is below 50°F (10°C) or above 90°F (32°C), perform temperature correction as follows:

1. In the Calculation Worksheet below, record the System Forward High and Low Balancing Carrier levels from the system map.
2. For both forward balancing carriers, note the loss (in dB at the carrier frequency) due to the cable preceding the unit under test. Also note the air temperature. Use these values and the TCV chart to obtain a TCV for this section of cable for each balancing carrier. Record both TCVs below.
3. Perform the calculation to get the corrected output levels.
4. Use the temperature-corrected forward balancing carrier levels for Forward Balancing or Forward Field Testing.
5. **Optional**: Repeat Steps 1 and 3 for the reverse balancing carriers. Use these temperature corrected levels for Reverse Balancing or Reverse Field Testing.

Calculation Worksheet:

______	+	______	=	______
System Forward High Balancing Carrier Level		TCV For High Carrier		Corrected Forward High Balancing Carrier Level
______	+	______	=	______
System Forward Low Balancing Carrier Level		TCV For Low Carrier		Corrected Forward Low Balancing Carrier Level

***Note**: The change in cable loss due to a temperature change is different at different frequencies. If the temperature changes more than 20° during balancing, recalculate the TCV.*



Temperature Correction Value Chart

***Note**: To quickly obtain the TCV , find the point on the chart corresponding to your cable loss and temperature values. Then, find the TCV lines nearest this point. The dB value label on that line is your TCV.*

6.2 Cable Specifications

6.2.1 Drop Cable

CommScope Drop Cable Loss

Frequency (MHz)	59 Series	6 Series	7 Series	11 Series
	dB cable loss per 100 ft / 100 m at 68°F			
5	0.86/2.82	0.58/1.90	0.47/1.54	0.38/1.25
55	2.05/6.73	1.60/5.25	1.25/4.10	0.96/3.15
83	2.45/8.04	1.95/6.40	1.5/4.92	1.18/3.87
300	4.45/14.60	3.55/11.64	2.82/9.25	2.25/7.38
350	4.80/15.75	3.85/12.63	3.05/10.01	2.42/7.94
400	5.10/16.73	4.15/13.61	3.27/10.73	2.60/8.53
450	5.40/17.72	4.40/14.43	3.46/11.35	2.75/9.02
500	5.70/18.70	4.66/15.09	3.67/12.04	2.90/9.51
550	5.95/19.52	4.90/16.08	3.85/12.63	3.04/9.97
750	6.97/22.87	5.65/18.54	4.57/14.99	3.65/11.97
865	7.52/24.67	6.10/20.01	4.93/16.17	3.98/13.05
1000	8.12/26.64	6.55/21.49	5.32/17.45	4.35/14.27
Vel. of Prop.	85% nominal			

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Times Fiber Communications T10 Drop Cable Loss

Frequency (MHz)	59 Series	6 Series	7 Series	11 Series
	dB cable loss per 100ft / 100m at 68°F			
5	0.77/2.53	0.57/1.87	0.56/1.84	0.36/1.18
45	1.75/5.74	1.39/4.56	1.15/3.77	0.89/2.92
55	1.88/6.18	1.50/4.94	1.22/4.00	0.95/3.12
83	2.31/7.58	1.85/6.07	1.50/4.92	1.17/3.84
150	3.03/9.94	2.42/7.94	1.93/6.33	1.53/5.02
300	4.27/14.01	3.43/11.25	2.74/8.99	2.17/7.12
330	4.50/14.76	3.61/11.84	2.89/9.47	2.29/7.51
400	4.88/16.01	4.00/13.12	3.20/10.50	2.53/8.30
450	5.30/17.39	4.28/14.04	3.41/11.19	2.69/8.83
500	5.50/18.04	4.51/14.8	3.61/11.84	2.85/9.35
550	5.90/19.36	4.7615.62	3.8/12.47	3.01/9.88
750	6.96/22.83	5.62/18.44	4.5/14.76	3.58/11.75
870	7.54/24.75	6.09/19.99	4.87/17.22	3.90/12.80
1000	8.09/26.54	6.54/21.46	5.25/17.22	4.23/13.88
Vel. of Prop.	85% nominal			

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Trilogy Communications Drop Cable Loss

Frequency (MHz)	59 Series	6 Series	7 Series	11 Series
	dB cable loss per 100ft / 100m at 68°F			
5	0.74/2.43	0.55/1.80	0.41/1.34	0.34/1.11
50	1.78/5.84	1.45/4.77	1.11/3.63	0.94/3.08
108	2.52/8.25	2.08/6.82	1.59/5.20	1.34/4.41
300	4.12/13.52	3.32/10.89	2.61/8.56	2.17/7.11
350	4.48/14.70	3.61/11.84	2.85/9.36	2.36/7.75
400	4.79/15.72	3.86/12.67	3.05/10.00	2.51/8.24
450	5.11/16.76	4.12/13.51	3.26/10.70	2.68/8.80
500	5.40/17.72	4.35/14.27	3.45/11.30	2.84/9.31
550	5.68/18.63	4.57/15.01	3.63/11.90	2.97/9.76
750	6.67/21.87	5.37/17.62	4.28/14.05	3.52/11.55
862	7.15/23.44	5.74/18.84	4.58/15.04	3.80/12.48
1000	7.74/25.41	6.23/20.45	4.99/16.37	4.18/13.71
Vel. of Prop.	85% nominal			

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6.2.2 Trunk and Distribution Cable

CommScope Parameter III Cable Loss

Frequency (MHz)	CommScope Parameter III Cable Dia. (in)				
	0.500	0.625	0.750	0.875	1.000
	dB cable loss per 100ft / 100m at 68°F				
5	0.16/0.52	0.13/0.43	0.11/0.36	0.09/0.30	0.08/0.26
45	0.49/1.61	0.41/1.34	0.33/1.08	0.28/0.92	0.25/0.82
55	0.54/1.77	0.46/1.51	0.37/1.21	0.33/1.08	0.31/1.02
83	0.66/2.17	0.57/1.87	0.46/1.51	0.41/1.35	0.39/1.28
150	0.90/2.95	0.77/2.53	0.62/2.03	0.55/1.80	0.52/1.71
250	1.20/3.94	1.00/3.28	0.81/2.66	0.72/2.36	0.65/2.13
350	1.43/4.69	1.18/3.87	0.97/3.18	0.84/2.76	0.78/2.56
400	1.53/5.02	1.27/4.17	1.05/3.44	0.91/2.99	0.84/2.76
450	1.63/5.35	1.35/4.43	1.12/3.67	0.97/3.18	0.90/2.95
550	1.82/5.97	1.50/4.92	1.24/4.07	1.08/3.54	1.01/3.31
750	2.16/7.09	1.78/5.84	1.48/4.86	1.29/4.23	1.21/3.97
865	2.34/7.68	1.93/6.33	1.61/5.28	1.41/4.63	1.34/4.40
1000	2.52/8.27	2.07/6.79	1.74/5.71	1.53/5.02	1.44/4.72
	Nominal DC Loop Resistance (ohms per 1000 ft/m) at 68°F				
Copper Clad	1.72/5.64	1.10/3.51	0.76/2.55	0.55/1.81	0.40/1.31
Solid Cop.	1.20/3.96	0.82/2.59	0.56/1.83	0.41/1.35	n/a
Vel. of Prop.	87% nominal				

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CommScope Quantum Reach Cable Loss

Frequency (MHz)	CommScope Quantum Reach Cable Dia. (in)			
	0.540	0.715	0.860	1.125
	dB cable loss per 100ft / 100m at 68°F			
5	0.14/0.46	0.11/0.36	0.09/0.30	0.07/0.23
45	0.41/1.35	0.33/1.08	0.29/0.95	0.21/0.69
55	0.47/1.54	0.36/1.18	0.32/1.05	0.23/0.76
83	0.58/1.90	0.45/1.48	0.40/1.31	0.29/0.95
150	0.79/2.59	0.61/2.00	0.54//1.77	0.41/1.35
250	1.03/3.38	0.81/2.66	0.70/2.30	0.54/1.77
350	1.23/4.03	0.97/3.18	0.83/2.72	0.65/2.13
400	1.32/4.33	1.05/3.44	0.88/2.89	0.70/2.30
450	1.40/4.59	1.12/3.67	0.95/3.12	0.75/2.46
550	1.56/5.12	1.25/4.10	1.06/3.48	0.84/2.76
750	1.85/6.07	1.49/4.89	1.24/4.07	1.01/3.31
865	2.00/6.56	1.62/5.31	1.33/4.36	1.11/3.64
1000	2.17/7.12	1.75/5.74	1.44/4.72	1.20/3.94
	Nominal DC Loop Resistance (ohms per 1000 ft/m) at 68°F			
Copper Clad	1.61/5.28	0.997/3.27	0.724/2.37	0.42/1.38
Solid Cop.	1.26/4.14	0.796/2.61	0.568/1.86	n/a
Vel. of Prop.	88% nominal			

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Trilogy Communication MC2 Cable Loss

Frequency (MHz)	MC^2 Cable Diameter (in.)				
	0.440	0.500	0.650	0.750	1.000
	dB cable loss per 100 ft / 100 m at 68°F				
5	0.17/0.56	0.14/0.46	0.11/0.36	0.10/0.33	0.07/0.23
30	0.41/1.35	0.35/1.15	0.28/0.92	0.25/0.82	0.18/0.59
55	0.56/1.84	0.48/1.57	0.38/1.25	0.34/1.08	0.24/0.79
83	0.69/2.26	0.59/1.94	0.47/1.54	0.41/1.35	0.30/0.98
211	1.11/3.64	0.95/3.12	0.76/2.49	0.66/2.17	0.49/1.61
250	1.21/3.97	1.03/3.38	0.83/2.72	0.72/2.36	0.54/1.77
350	1.44/4.72	1.23/4.04	0.99/3.25	0.86/2.82	0.65/2.13
450	1.64/5.38	1.40/4.59	1.13/3.71	0.97/3.18	0.74/2.43
550	1.81/5.94	1.55/5.09	1.25/4.10	1.08/3.54	0.82/2.69
750	2.13/6.99	1.83/6.00	1.50/4.92	1.25/4.10	0.97/3.18
900	2.36/7.74	2.03/6.66	1.67/5.48	1.39/4.56	1.09/3.58
1000	2.49/8.17	2.15/7.05	1.77/5.81	1.47/4.82	1.16/3.81
	Nominal DC Loop Resistance (ohms per 1000 ft/m) at 68°F				
Copper Clad Alum.	1.95/6.40	1.55/5.09	1.00/3.28	0.69/2.26	0.41/1.35
Vel. of Prop.	93% nominal				

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Times Fiber T10 Semiflex Communication Cable Loss (dB/100 ft at 68°F)

Frequency (MHz)	T10 SEMIFLEX Cable Diameter (in)				
	0.500	0.625	0.750	0.875	1.000
	dB cable loss per 100ft / 100m at 68°F				
5	0.16/0.52	0.13/0.43	0.11/0.36	0.09/0.30	0.08/0.26
45	0.49/1.61	0.40/1.31	0.33/1.08	0.29/0.95	0.26/0.85
55	0.55/1.80	0.45/1.46	0.37/1.21	0.32/1.04	0.29/0.95
83	0.67/2.22	0.55/1.80	0.45/1.48	0.39/1.28	0.35/1.15
211	1.08/3.55	0.89/2.92	0.73/2.41	0.64/2.09	0.58/1.92
250	1.19/3.92	0.98/3.22	0.81/2.65	0.70/2.31	0.64/2.11
350	1.43/4.69	1.18/3.87	0.97/3.18	0.84/2.76	0.78/2.56
450	1.63/5.35	1.35/4.43	1.12/3.67	0.97/3.18	0.90/2.95
550	1.82/5.97	1.51/4.95	1.25/4.10	1.09/3.58	1.01/3.31
750	2.16/7.09	1.79/5.87	1.48/4.86	1.29/4.23	1.213.97
870	2.35/7.69	1.95/6.40	1.61/5.28	1.41/4.63	1.33/4.35
1000	2.53/8.30	2.11/6.92	1.74/5.71	1.53/5.02	1.44/4.72
	Nominal DC Loop Resistance (ohms per 1000 ft/m) at 68°F				
Copper-clad	1.70/5.58	1.09/3.58	0.75/2.46	0.55/1.80	0.41/1.35
Vel. of Prop.	87% nominal				

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Times Fiber TX10 Semiflex Communication Cable Loss

Frequency (MHz)	TX10 SEMIFLEX Cable Diameter (in)			
	0.565	0.700	0.840	1.160
	dB cable loss per 100 ft / 100 m at 68°F			
5	0.14/0.46	0.11/0.36	0.09/0.30	0.07/0.23
45	0.42/1.38	0.33/1.08	0.28/0.92	0.21/0.69
55	0.47/1.55	0.37/1.21	0.32/1.04	0.24/0.78
83	0.58/1.90	0.45/1.48	0.39/1.28	0.29/0.95
211	0.93/3.06	0.74/2.43	0.64/2.09	0.48/1.58
250	1.03/3.38	0.82/2.68	0.70/2.31	0.53/1.76
350	1.23/4.04	0.98/3.21	0.84/2.76	0.65/2.13
450	1.40/4.59	1.12/3.67	0.97/3.18	0.75/2.46
550	1.56/5.12	1.25/4.10	1.09/3.58	0.84/2.76
750	1.85/6.07	1.49/4.89	1.30/4.27	1.01/3.31
870	2.01/6.58	1.62/5.31	1.41/4.63	1.11/3.64
1000	2.17/7.12	1.75/5.74	1.53/5.02	1.20/3.94
	Nominal DC Loop Resistance (ohms per 1000 ft/m) at 68°F			
Copper-clad	1.30/4.27	0.85/2.79	0.60/1.97	0.30/0.98
Vel. of Prop.	89% nominal			

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6.3 RF Taps and Passives

6.3.1 Couplers and Splitters (9-TFC Series)

All specifications in this section reflect nominal performance for design purposes and are subject to change without notice.

9-TFC Series Directional Coupler Losses (dB)

	Model	9-TFC-8	9-TFC-12	9-TFC-16
Insertion Loss (input/output port)	5 MHz	1.7	0.9	0.7
	30 MHz	1.6	0.8	0.7
	54 MHz	1.5	0.8	0.6
	112 MHz	1.8	1.0	0.9
	330 MHz	1.8	1.0	0.9
	450 MHz	1.9	1.1	0.9
	550 MHz	2.0	1.1	0.9
	600 MHz	2.1	1.3	1.1
	750 MHz	2.4	1.5	1.2
	862 MHz	2.6	1.8	1.4
	1000 MHz	3.0	2.0	1.6
Tap Loss (input/tap port)	5 -19 MHz	8.5	12.5	16.6
	20-899 MHz	8.2	11.9	16.0
	900-1000 MHz	8.3	12.2	16.1

9-TFC Series Splitter (5-1000 MHz) Losses (dB)

	Model	9-TFC-4	9-TFC-488[1]		9-TFC-777
			A	B	
Insertion Loss (input/output port)	5 MHz	3.7	3.7	7.2	5.6
	30 MHz	3.5	3.7	7.1	5.5
	54 MHz	3.5	3.6	7.1	5.4
	112 MHz	3.6	3.7	7.2	5.5
	330 MHz	3.8	3.9	7.4	5.9
	400 MHz	3.8	3.9	7.4	5.9
	450 MHz	3.9	4.0	7.4	6.0
	550 MHz	4.0	4.1	7.5	6.0
	600 MHz	4.1	4.2	7.7	6.2
	750 MHz	4.3	4.5	8.0	6.5
	862 MHz	4.5	4.6	8.4	7.1
	1000 MHz	4.8	5.1	8.8	7.8

[1] Value in column A refers to losses between Input and High Output. Value in column B refers to losses between Input and Low Output.

6.3.2 Power Bypass Taps (9000-L-PBT Series)

All specifications in this section reflect worst case performance for design purposes and are subject to change without notice.

9800-L-PBT Series 8-Way Multi-Tap Insertion Loss (dB)

	Model	9812	9815	9818	9821	9824
	Tap Value	12.0	15.5	18.0	21.0	24.0
	Color Code	Gold	White	Blue	Green	Purple
Insertion Loss (input/output port)	5 MHz	–	3.8	2.2	1.4	1.0
	10 MHz	–	3.8	2.1	1.2	0.8
	30 MHz	–	3.5	2.5	1.0	0.7
	50 MHz	–	3.5	1.9	1.0	0.7
	100 MHz	–	4.0	1.8	1.2	0.7
	330 MHz	–	4.2	2.1	1.3	0.9
	450 MHz	–	4.4	2.3	1.3	0.9
	550 MHz	–	4.5	2.4	1.4	1.1
	600 MHz	–	4.7	2.6	1.4	1.1
	750 MHz	–	5.1	2.8	1.6	1.3
	862 MHz	–	5.3	3.2	1.8	1.4
	1000 MHz	–	5.4	3.5	2.2	1.8
In/Out Return Loss	5 to 10 MHz	15	13	15	15	15
	10 to 30 MHz	17	18	17	17	17
	30 to 600 MHz	18	18	18	18	18
	600 to 900 MHz	17	17	17	17	17
	900 to 1000 MHz	15	15	15	15	15
Tap Return Loss	5 to 10 MHz	15	15	15	15	15
	10 to 30 MHz	15	15	15	15	15
	30 to 600 MHz	18	18	18	18	18
	600 to 900 MHz	16	16	16	16	16
	900 to 1000 MHz	15	15	15	15	15

See page 6-17 for Models 9827 and 9830.

9800-L-PBT Series 8-Way Multi-Tap Insertion Loss (dB)

	Model	**9827**	**9830**
	Tap Value	**27.0**	**30.0**
	Color Code	**Yellow**	**Red**
Insertion Loss (input/output port)	5 MHz	0.9	0.8
	10 MHz	0.8	0.7
	30 MHz	0.7	0.7
	50 MHz	0.7	0.7
	100 MHz	0.7	0.7
	330 MHz	0.8	0.8
	450 MHz	0.9	0.9
	550 MHz	1.0	0.9
	600 MHz	1.1	0.9
	750 MHz	1.2	1.2
	862 MHz	1.4	1.4
	1000 MHz	1.6	1.4
In/Out Return Loss	5 to 10 MHz	15	15
	10 to 30 MHz	17	17
	30 to 600 MHz	18	18
	600 to 900 MHz	17	17
	900 to 1000 MHz	15	15
Tap Return Loss	5 to 10 MHz	15	15
	10 to 30 MHz	15	15
	30 to 600 MHz	18	18
	600 to 900 MHz	16	16
	900 to 1000 MHz	15	15

See page 6-16 for Models 9812, 9815, 9818, 9821, and 9824.

9400-L-PBT Series 4-Way Multi-Tap Insertion Loss (dB)

	Model	9408	9411	9414	9417	9420
	Tap Value	8.0	11.5	14.0	17.0	20.0
	Color Code	Orange	Gold	White	Blue	Green
Insertion Loss (input/output port)	5 MHz	–	3.8	2.1	1.5	1.1
	10 MHz	–	3.6	2.0	1.4	1.0
	30 MHz	–	3.5	1.8	1.1	0.7
	50 MHz	–	3.5	1.8	1.1	0.7
	100 MHz	–	4.0	1.8	1.1	0.8
	330 MHz	–	4.3	2.3	1.4	1.0
	450 MHz	–	4.3	2.3	1.4	1.0
	550 MHz	–	4.4	2.4	1.5	1.1
	600 MHz	–	4.7	2.5	1.5	1.1
	750 MHz	–	5.1	2.7	1.6	1.2
	862 MHz	–	5.2	3.0	1.8	1.4
	1000 MHz	–	5.4	3.3	2.1	1.6
In/Out Return Loss	5 to 10 MHz	15	13	15	15	15
	10 to 30 MHz	17	16	17	17	17
	30 to 600 MHz	18	18	18	18	18
	600 to 900 MHz	17	17	17	17	17
	900 to 1000 MHz	15	15	15	15	15
Tap Return Loss	5 to 10 MHz	15	15	15	15	15
	10 to 30 MHz	16	16	16	16	16
	30 to 600 MHz	18	18	18	18	18
	600 to 900 MHz	16	16	16	16	16
	900 to 1000 MHz	15	15	15	15	15

See page 6-19 for Models 9423, 9426, 9429, 9432, and 9435.

9400-L-PBT Series 4-Way Multi-Tap Insertion Loss (dB)

	Model	9423	9426	9429	9432	9435
	Tap Value	23.0	26.0	29.0	32.0	35.0
	Color Code	Purple	Yellow	Red	Silver	Brown
Insertion Loss (input/output port)	5 MHz	1.1	0.8	0.8	0.8	0.8
	10 MHz	1.0	0.7	0.7	0.7	0.7
	30 MHz	0.7	0.5	0.5	0.5	0.5
	50 MHz	0.7	0.5	0.5	0.5	0.5
	100 MHz	0.7	0.5	0.5	0.5	0.5
	330 MHz	0.9	0.8	0.8	0.8	0.8
	450 MHz	0.9	0.8	0.8	0.8	0.8
	550 MHz	1.0	0.9	0.9	0.9	0.9
	600 MHz	1.0	0.9	0.9	0.9	0.9
	750 MHz	1.2	1.0	1.0	1.0	1.0
	862 MHz	1.4	1.1	1.1	1.1	1.1
	1000 MHz	1.6	1.4	1.4	1.4	1.4
In/Out Return Loss	5 to 10 MHz	15	15	15	15	15
	10 to 30 MHz	17	17	17	17	17
	30 to 600 MHz	18	18	18	18	18
	600 to 900 MHz	17	17	17	17	17
	900 to 1000 MHz	15	15	15	15	15
Tap Return Loss	5 to 10 MHz	15	15	15	15	15
	10 to 30 MHz	16	16	16	16	16
	30 to 600 MHz	18	18	18	18	18
	600 to 900 MHz	16	16	16	16	16
	900 to 1000 MHz	15	15	15	15	15

See page 6-18 for Models 9408, 9411, 9414, 9417, and 9420.

9200-L-PBT Series 2-Way Multi-Tap Insertion Loss (dB)

	Model	9204	9208	9211	9214	9217
	Tap Value	4.0	8.0	11.0	14.0	17.0
	Color Code	Black	Orange	Gold	White	Blue
Insertion Loss (input/output port)	5 MHz	–	3.5	2.1	1.2	1.0
	10 MHz	–	3.4	2.0	1.0	0.9
	30 MHz	–	3.3	1.9	0.9	0.7
	50 MHz	–	3.3	1.8	0.9	0.7
	100 MHz	–	3.3	1.8	0.9	0.8
	330 MHz	–	3.8	2.0	1.1	1.0
	450 MHz	–	4.0	2.2	1.1	1.1
	550 MHz	–	4.2	2.3	1.2	1.1
	600 MHz	–	4.3	2.4	1.3	1.2
	750 MHz	–	4.7	2.6	1.4	1.3
	862 MHz	–	5.1	2.8	1.6	1.5
	1000 MHz	–	5.4	3.2	1.9	1.6
In/Out Return Loss	5 to 10 MHz	15	14	15	15	15
	10 to 30 MHz	17	17	17	17	17
	30 to 600 MHz	18	18	18	18	18
	600 to 900 MHz	17	17	17	17	17
	900 to 1000 MHz	15	15	15	15	15
Tap Return Loss	5 to 10 MHz	15	13	15	15	15
	10 to 30 MHz	16	16	16	16	16
	30 to 600 MHz	18	18	18	18	18
	600 to 900 MHz	16	16	16	16	16
	900 to 1000 MHz	15	15	15	15	15

See page 6-21 for Models 9220, 9223, 9226, 9229, and 9232.

9200-L-PBT Series 2-Way Multi-Tap Insertion Loss (dB)

	Model	9220	9223	9226	9229	9232
	Tap Value	20.0	23.0	26.0	29.0	32.0
	Color Code	Green	Purple	Yellow	Red	Silver
Insertion Loss (input/output port)	5 MHz	1.1	0.8	0.8	0.8	0.8
	10 MHz	1.0	0.6	0.6	0.6	0.6
	30 MHz	0.7	0.6	0.6	0.6	0.6
	50 MHz	0.7	0.6	0.6	0.6	0.6
	100 MHz	0.8	0.6	0.6	0.6	0.6
	330 MHz	0.9	0.7	0.7	0.7	0.7
	450 MHz	0.9	0.8	0.8	0.8	0.8
	550 MHz	1.0	0.9	0.9	0.9	0.9
	600 MHz	1.0	0.9	0.9	0.9	0.9
	750 MHz	1.2	1.0	1.0	1.0	1.0
	862 MHz	1.4	1.2	1.2	1.2	1.2
	1000 MHz	1.6	1.4	1.4	1.4	1.4
In/Out Return Loss	5 to 10 MHz	15	15	15	15	15
	10 to 30 MHz	17	17	17	17	17
	30 to 600 MHz	18	18	18	18	18
	600 to 900 MHz	17	17	17	17	17
	900 to 1000 MHz	15	15	15	15	15
Tap Return Loss	5 to 10 MHz	15	15	15	15	15
	10 to 30 MHz	16	16	16	16	16
	30 to 600 MHz	18	18	18	18	18
	600 to 900 MHz	16	16	16	16	16
	900 to 1000 MHz	15	15	15	15	15

See page 6-20 for Models 9204, 9208, 9211, 9214, and 9217.

6.3.3 Telephony Twisted-Pair Taps (9000T-TP Series)

All specifications in this section reflect nominal performance for design purposes and are subject to change without notice.

9800T-TP Series 8-Way Multi-Tap Insertion Loss (dB)

	Model	9812	9815	9818	9821	9824
	Tap Value	12.0	15.0	18.0	21.0	24.0
	Color Code	Gold	White	Blue	Green	Purple
Insertion Loss (input/output port)	10 MHz	–	2.6	1.4	0.8	0.5
	30 MHz	–	2.5	1.3	0.7	0.4
	54 MHz	–	2.4	1.2	0.6	0.4
	70 MHz	–	2.6	1.4	0.8	0.6
	112 MHz	–	2.9	1.7	1.0	0.8
	150 MHz	–	2.9	1.7	1.0	0.8
	186 MHz	–	2.9	1.7	1.0	0.8
	222 MHz	–	3.0	1.8	1.1	0.8
	330 MHz	–	3.0	1.9	1.1	0.8
	400 MHz	–	3.1	1.9	1.2	0.8
	450 MHz	–	3.1	1.9	1.2	0.8
	550 MHz	–	3.3	2.1	1.3	0.9
	600 MHz	–	3.5	2.1	1.3	0.9
	750 MHz	–	3.9	2.4	1.5	1.1
	862 MHz	–	4.1	2.7	1.7	1.3
	1000 MHz	–	4.3	3.0	2.2	1.7
Tap Loss (input/tap port)	10 to 19 MHz	11.0	15.3	17.9	21.4	24.1
	20 to 899 MHz	11.3	15.1	17.6	21.1	23.7
	900 to 1000 MHz	12.5	16.2	18.7	21.9	24.2

See page 6-23 for Models 9827, 9830, 9833, and 9836.

9800T-TP Series 8-Way Multi-Tap Insertion Loss (dB)

	Model	9827	9830	9833	9836
	Tap Value	27.0	30.0	33.0	36.0
	Color Code	Yellow	Red	Silver	Brown
Insertion Loss (input/output port)	10 MHz	0.5	0.4	0.3	0.4
	30 MHz	0.4	0.3	0.3	0.3
	54 MHz	0.3	0.3	0.3	0.3
	70 MHz	0.4	0.3	0.3	0.3
	112 MHz	0.5	0.4	0.4	0.4
	150 MHz	0.5	0.4	0.4	0.4
	186 MHz	0.5	0.4	0.4	0.4
	222 MHz	0.5	0.4	0.4	0.4
	330 MHz	0.5	0.4	0.4	0.4
	400 MHz	0.6	0.5	0.5	0.5
	450 MHz	0.6	0.5	0.5	0.5
	550 MHz	0.6	0.5	0.5	0.5
	600 MHz	0.7	0.7	0.7	0.7
	750 MHz	0.8	0.7	0.8	0.7
	862 MHz	0.9	0.8	0.8	0.8
	1000 MHz	1.1	1.0	1.0	1.0
Tap Loss (input/tap port)	10 to 19 MHz	25.9	28.8	31.7	34.7
	20 to 899 MHz	26.9	30.1	32.5	35.6
	900 to 1000 MHz	27.4	30.3	33.0	36.3

See page 6-22 for Models 9812, 9815, 9818, 9821, and 9824.

9400T-TP Series 4-Way Multi-Tap Insertion Loss (dB)

	Model	9408	9411	9414	9417	9420
	Tap Value	8.0	11.5	14.5	17.0	20.0
	Color Code	Orange	Gold	White	Blue	Green
Insertion Loss (input/output port)	10 MHz	–	3.2	1.4	0.7	0.5
	30 MHz	–	3.2	1.3	0.6	0.4
	54 MHz	–	3.2	1.2	0.6	0.4
	70 MHz	–	3.5	1.4	0.8	0.6
	112 MHz	–	3.7	1.6	0.9	0.8
	186 MHz	–	3.8	1.6	0.9	0.8
	222 MHz	–	3.8	1.6	0.9	0.8
	330 MHz	–	3.9	1.7	1.0	0.8
	400 MHz	–	4.0	1.8	1.0	0.8
	450 MHz	–	4.0	1.8	1.0	0.8
	550 MHz	–	4.1	1.9	1.1	0.9
	600 MHz	–	4.4	2.0	1.2	0.9
	750 MHz	–	4.6	2.4	1.4	1.1
	862 MHz	–	4.5	2.8	1.5	1.3
	1000 MHz	–	4.4	3.4	2.0	1.7
Tap Loss (input/tap port)	10 to 19 MHz	6.8	10.7	14.9	17.5	20.2
	20 to 899 MHz	7.2	10.5	14.9	17.2	19.8
	900 to 1000 MHz	8.6	13.3	15.7	17.7	20.7

See page 6-25 for Models 9423, 9426, 9429, 9432, and 9435.

9400T-TP Series 4-Way Multi-Tap Insertion Loss (dB)

	Model	9423	9426	9429	9432	9435
	Tap Value	23.0	26.0	29.0	32.0	35.0
	Color Code	Purple	Yellow	Red	Silver	Brown
Insertion Loss (input/output port)	10 MHz	0.4	0.4	0.3	0.3	0.3
	30 MHz	0.4	0.3	0.3	0.3	0.3
	54 MHz	0.4	0.3	0.3	0.3	0.3
	70 MHz	0.6	0.3	0.3	0.3	0.3
	112 MHz	0.7	0.4	0.4	0.4	0.4
	186 MHz	0.7	0.4	0.4	0.4	0.4
	222 MHz	0.7	0.4	0.4	0.4	0.4
	330 MHz	0.7	0.5	0.5	0.5	0.5
	400 MHz	0.7	0.5	0.5	0.5	0.5
	450 MHz	0.7	0.5	0.5	0.5	0.5
	550 MHz	0.8	0.6	0.5	0.5	0.5
	600 MHz	0.8	0.6	0.6	0.6	0.6
	750 MHz	1.0	0.8	0.8	0.7	0.8
	862 MHz	1.1	0.9	0.9	0.8	0.9
	1000 MHz	1.6	1.1	1.0	0.9	1.1
Tap Loss (input/tap port)	10 to 19 MHz	23.3	25.4	28.3	31.4	34.4
	20 to 899 MHz	22.8	26.1	29.1	32.0	35.0
	900 to 1000 MHz	23.8	25.9	29.5	32.2	34.9

See page 6-24 for Models 9408, 9411, 9414, 9417, and 9420.

9200T-TP Series 2-Way Multi-Tap Insertion Loss (dB)

	Model	9204	9208	9211	9214	9217
	Tap Value	4.0	8.5	11.0	14.0	17.0
	Color Code	Black	Orange	Gold	White	Blue
Insertion Loss (input/output port)	10 MHz	–	2.7	1.3	0.6	0.5
	30 MHz	–	2.7	1.2	0.6	0.4
	54 MHz	–	2.6	1.2	0.6	0.4
	70 MHz	–	2.9	1.4	0.7	0.6
	112 MHz	–	3.1	1.6	0.9	0.8
	150 MHz	–	3.3	1.6	0.9	0.8
	186 MHz	–	3.3	1.6	0.9	0.8
	222 MHz	–	3.3	1.6	0.9	0.8
	330 MHz	–	3.3	1.6	1.0	0.8
	400 MHz	–	3.4	1.7	1.0	0.8
	450 MHz	–	3.4	1.7	1.0	0.8
	550 MHz	–	3.5	1.8	1.0	0.8
	600 MHz	–	3.6	1.9	1.1	0.9
	750 MHz	–	3.9	2.2	1.3	1.1
	862 MHz	–	4.1	2.4	1.4	1.3
	1000 MHz	–	4.0	2.9	1.8	1.7
Tap Loss (input/tap port)	10 to 19 MHz	3.4	7.6	11.3	14.8	17.1
	20 to 899 MHz	3.6	7.5	11.2	14.7	16.6
	900 to 1000 MHz	4.5	9.2	12.1	15.0	17.0

See page 6-27 for Models 9220, 9223, 9226, 9229, and 9232.

9200T-TP Series 2-Way Multi-Tap Insertion Loss (dB)

	Model	9220	9223	9226	9229	9232
	Tap Value	20.0	23.0	26.0	29.0	32.0
	Color Code	Green	Purple	Yellow	Red	Silver
Insertion Loss (input/output port)	10 MHz	0.4	0.3	0.3	0.3	0.3
	30 MHz	0.4	0.3	0.3	0.3	0.3
	54 MHz	0.3	0.3	0.3	0.3	0.3
	70 MHz	0.4	0.3	0.3	0.3	0.3
	112 MHz	0.7	0.5	0.4	0.4	0.4
	150 MHz	0.5	0.4	0.4	0.4	0.4
	186 MHz	0.5	0.4	0.4	0.4	0.4
	222 MHz	0.5	0.4	0.4	0.4	0.4
	330 MHz	0.5	0.5	0.4	0.4	0.5
	400 MHz	0.6	0.5	0.5	0.5	0.5
	450 MHz	0.6	0.5	0.5	0.5	0.5
	550 MHz	0.6	0.5	0.5	0.5	0.5
	600 MHz	0.7	0.6	0.6	0.6	0.6
	750 MHz	0.9	0.8	0.7	0.8	0.8
	862 MHz	1.0	0.8	0.8	0.8	0.9
	1000 MHz	1.1	1.0	0.9	0.9	1.0
Tap Loss (input/tap port)	10 to 19 MHz	19.6	22.3	25.2	28.3	31.3
	20 to 899 MHz	20.3	23.0	25.9	28.8	31.7
	900 to 1000 MHz	21.0	23.7	27.2	29.7	32.9

See page 6-26 for Models 9204, 9208, 9211, 9214, and 9217.

6.3.4 Telephony F-Port Taps (9000T-FP Series)

All specifications in this section reflect nominal performance for design purposes and are subject to change without notice.

9800T-FP Series 8-Way Multi-Tap Insertion Loss (dB)

	Model	9812	9815	9818	9821	9824
	Tap Value	**12.0**	**15.5**	**18.0**	**21.0**	**24.0**
	Color Code	**Gold**	**White**	**Blue**	**Green**	**Purple**
Insertion Loss (input/output port)	10 MHz	–	3.5	1.4	1.1	0.9
	30 MHz	–	3.4	1.3	0.9	0.7
	54 MHz	–	3.4	1.3	0.9	0.7
	112 MHz	–	3.8	1.7	1.0	0.8
	150 MHz	–	3.8	1.7	1.0	0.8
	186 MHz	–	3.9	1.8	1.0	0.8
	222 MHz	–	3.9	1.8	1.1	0.8
	330 MHz	–	4.0	1.9	1.1	0.8
	400 MHz	–	4.1	2.0	1.1	0.8
	450 MHz	–	4.1	2.0	1.1	0.9
	550 MHz	–	4.2	2.0	1.1	0.9
	600 MHz	–	4.5	2.2	1.2	0.9
	750 MHz	–	4.9	2.6	1.3	1.0
	862 MHz	–	5.0	2.9	1.5	1.2
	1000 MHz	–	5.2	3.5	1.7	1.2
Tap Loss (input/tap port)	10 to 19 MHz	10.7	13.8	17.8	19.4	22.3
	20 to 899 MHz	11.3	14.6	18.4	20.6	24.3
	900 to 1000 MHz	13.0	16.7	18.8	20.7	25.1

See page 6-27 for Models 9827, 9830, 9833, and 9836.

9800T-FP Series 8-Way Multi-Tap Insertion Loss (dB)

	Model	9827	9830	9833	9836
	Tap Value	27.0	30.0	33.0	36.0
	Color Code	Yellow	Red	Silver	Brown
Insertion Loss (input/output port)	10 MHz	0.7	0.3	0.3	0.3
	30 MHz	0.6	0.3	0.3	0.3
	54 MHz	0.5	0.3	0.3	0.3
	112 MHz	0.7	0.4	0.5	0.4
	150 MHz	0.7	0.4	0.5	0.4
	186 MHz	0.7	0.4	0.5	0.4
	222 MHz	0.7	0.4	0.5	0.4
	330 MHz	0.7	0.5	0.5	0.5
	400 MHz	0.7	0.5	0.5	0.5
	450 MHz	0.7	0.6	0.6	0.5
	550 MHz	0.7	0.6	0.6	0.5
	600 MHz	0.8	0.7	0.7	0.6
	750 MHz	0.9	0.8	0.8	0.8
	862 MHz	1.1	1.0	1.0	1.0
	1000 MHz	1.1	1.1	1.1	1.1
Tap Loss (input/tap port)	10 to 19 MHz	25.5	28.8	32.2	34.5
	20 to 899 MHz	26.7	30.4	32.8	35.6
	900 to 1000 MHz	27.8	30.4	33.2	36.3

See page 6-28 for Models 9812, 9815, 9818, 9821, and 9824.

9400T-FP Series 4-Way Multi-Tap Insertion Loss (dB)

	Model	9408	9411	9414	9417	9420
	Tap Value	8.0	11.5	14.5	17.0	20.0
	Color Code	Orange	Gold	White	Blue	Green
Insertion Loss (input/output port)	10 MHz	–	3.5	1.3	1.0	0.9
	30 MHz	–	3.4	1.3	0.7	0.7
	54 MHz	–	3.4	1.3	0.7	0.7
	112 MHz	–	3.8	1.7	0.9	0.8
	150 MHz	–	3.8	1.7	0.9	0.8
	186 MHz	–	3.9	1.8	0.9	0.9
	222 MHz	–	3.9	1.8	0.9	0.9
	330 MHz	–	4.0	1.8	0.9	0.9
	400 MHz	–	4.1	1.8	1.0	0.9
	450 MHz	–	4.1	1.8	1.0	0.9
	550 MHz	–	4.2	1.9	1.0	0.9
	600 MHz	–	4.4	2.1	1.1	0.9
	750 MHz	–	4.7	2.6	1.3	1.1
	862 MHz	–	4.8	3.0	1.6	1.3
	1000 MHz	–	4.9	3.6	1.8	1.3
Tap Loss (input/tap port)	10 to 19 MHz	6.9	10.3	14.5	15.8	19.4
	20 to 899 MHz	7.2	10.7	14.7	17.6	21.0
	900 to 1000 MHz	8.2	12.8	15.0	18.2	20.7

See page 6-31 for Models 9423, 9426, 9429, 9432, and 9435.

9400T-FP Series 4-Way Multi-Tap Insertion Loss (dB)

	Model	9423	9426	9429	9432	9435
	Tap Value	23.0	26.0	29.0	32.0	35.0
	Color Code	Purple	Yellow	Red	Silver	Brown
Insertion Loss (input/output port)	10 MHz	0.6	0.3	0.3	0.3	0.3
	30 MHz	0.6	0.3	0.3	0.3	0.3
	54 MHz	0.6	0.3	0.3	0.3	0.3
	112 MHz	0.7	0.5	0.5	0.5	0.5
	150 MHz	0.7	0.5	0.5	0.5	0.5
	186 MHz	0.7	0.5	0.5	0.5	0.5
	222 MHz	0.7	0.5	0.5	0.5	0.5
	330 MHz	0.7	0.5	0.5	0.5	0.5
	400 MHz	0.8	0.5	0.6	0.6	0.5
	450 MHz	0.8	0.5	0.6	0.6	0.5
	550 MHz	0.8	0.6	0.6	0.6	0.6
	600 MHz	0.8	0.6	0.6	0.7	0.6
	750 MHz	1.0	0.9	0.8	0.8	0.8
	862 MHz	1.1	1.1	1.0	1.0	1.0
	1000 MHz	1.1	1.1	1.0	1.0	1.0
Tap Loss (input/tap port)	10 to 19 MHz	22.1	24.9	27.9	31.0	34.2
	20 to 899 MHz	23.6	26.3	29.2	32.2	35.3
	900 to 1000 MHz	23.2	26.0	29.1	32.0	35.2

See page 6-30 for Models 9408, 9411, 9414, 9417, and 9420.

9200T-FP Series 2-Way Multi-Tap Insertion Loss (dB)

	Model	9204	9208	9211	9214	9217
	Tap Value	4.0	8.5	11.0	14.0	17.0
	Color Code	Black	Orange	Gold	White	Blue
Insertion Loss (input/output port)	10 MHz	–	2.8	1.3	1.0	0.9
	30 MHz	–	2.8	1.3	0.8	0.7
	54 MHz	–	2.8	1.3	0.7	0.7
	112 MHz	–	3.2	1.7	0.9	0.8
	150 MHz	–	3.2	1.7	0.9	0.8
	186 MHz	–	3.2	1.7	0.9	0.8
	222 MHz	–	3.3	1.7	0.9	0.9
	330 MHz	–	3.4	1.8	0.9	0.9
	400 MHz	–	3.4	1.9	1.0	0.9
	450 MHz	–	3.4	1.9	1.0	0.9
	550 MHz	–	3.5	1.9	1.0	0.9
	600 MHz	–	3.8	2.1	1.1	1.0
	750 MHz	–	4.3	2.5	1.2	1.2
	862 MHz	–	4.5	2.8	1.4	1.3
	1000 MHz	–	4.8	3.5	1.6	1.3
Tap Loss (input/tap port)	10 to 19 MHz	3.4	7.7	10.8	13.7	15.7
	20 to 899 MHz	3.7	8.0	11.1	14.9	17.4
	900 to 1000 MHz	5.2	9.6	11.0	15.2	17.0

See page 6-33 for Models 9220, 9223, 9226, 9229, and 9232.

9200T-FP Series 2-Way Multi-Tap Insertion Loss (dB)

	Model	9220	9223	9226	9229	9232
	Tap Value	20.0	23.0	26.0	29.0	32.0
	Color Code	Green	Purple	Yellow	Red	Silver
Insertion Loss (input/output port)	10 MHz	0.7	0.3	0.3	0.3	0.3
	30 MHz	0.6	0.3	0.3	0.3	0.3
	54 MHz	0.6	0.3	0.3	0.3	0.3
	112 MHz	0.7	0.5	0.5	0.4	0.4
	150 MHz	0.7	0.5	0.5	0.4	0.4
	186 MHz	0.7	0.5	0.5	0.4	0.4
	222 MHz	0.8	0.5	0.5	0.5	0.5
	330 MHz	0.8	0.5	0.5	0.5	0.5
	400 MHz	0.8	0.6	0.6	0.5	0.5
	450 MHz	0.8	0.6	0.6	0.5	0.5
	550 MHz	0.8	0.6	0.6	0.5	0.6
	600 MHz	0.9	0.6	0.6	0.6	0.6
	750 MHz	1.0	0.8	0.8	0.7	0.8
	862 MHz	1.1	0.9	0.9	0.9	1.0
	1000 MHz	1.1	1.0	1.0	1.0	1.1
Tap Loss (input/tap port)	10 to 19 MHz	18.4	21.2	24.4	27.2	30.5
	20 to 899 MHz	20.0	22.6	25.5	28.1	31.2
	900 to 1000 MHz	20.0	23.2	26.5	29.1	32.8

See page 6-32 for Models 9204, 9208, 9211, 9214, and 9217.

C-COR Main Line Passives, LS Series

				Loss in dB at Frequency (MHz)								
Model Number	**Parameter**	**Port**	**Spec**	**5**	**10**	**50**	**300**	**450**	**550**	**750**	**860**	**1000**
LS-15G-2 (2-Way Splitter)	Insert. Loss	1-3, 1-4	Max.	3.95	3.91	3.80	4.16	4.20	4.30	4.50	4.70	4.90
	Isolation	3-4	Min.	22	22	22	22	22	22	22	22	22
LS-15G-3 (3-Way Splitter)	Insert. Loss	1-3	Max.	3.95	3.81	3.80	4.16	4.20	4.30	4.50	4.70	4.90
	Insert. Loss	1-2, 1-4	Max.	7.35	7.20	7.15	7.55	7.55	7.60	7.90	8.20	8.65
	Isolation	2-3, 2-4	Min.	22	22	22	22	22	22	22	22	22
LS-15G-DC-8 (Directional Coupler)	Insert. Loss	1-3	Max.	2.20	2.10	2.00	2.20	2.20	2.30	2.53	2.60	2.85
	Tap	1-4	Max.	8.48	8.48	8.50	8.60	8.65	8.70	8.75	8.87	9.10
	Isolation	3-4	Min.	18	22	22	22	22	22	22	22	22

C-COR Main Line Passives, LS Series

Model Number	Parameter	Port	Spec	Loss in dB at Frequency (MHz)								
				5	10	50	300	450	550	750	860	1000
LS-15G-DC-12 (Directional Coupler)	Insert. Loss	1-3	Max.	1.25	1.15	1.15	1.35	1.39	1.50	1.74	1.86	2.00
	Tap	1-4	Max.	12.20	12.20	12.30	12.40	12.40	12.40	12.50	12.50	12.55
	Isolation	3-4	Min.	26	26	26	22	22	22	22	22	22
LS-15G-DC-16 (Directional Coupler)	Insert. Loss	1-3	Max.	1.17	1.02	1.02	1.12	1.21	1.25	1.35	1.38	1.68
	Tap	1-4	Max.	15.90	16.00	16.10	16.30	16.10	16.10	16.20	16.20	16.60
	Isolation	3-4	Min.	23	25	25	25	25	25	22	22	22
LSB-15G-MC (Splice Box)	Insert. Loss	1-3	Max.	0.10	0.10	0.10	0.10	0.15	0.17	0.22	0.22	0.25
LS-15G-C (Power Inserter)	Insert. Loss	1-3	Max.	0.60	0.40	0.45	0.60	0.80	0.90	1.00	1.05	1.15
	Isolation	3-4	Min.	70	70	70	65	60	60	60	60	60
Return Loss All Ports:			Min.	18	18	20	20	20	20	20	20	20

C-COR Feeder Line Equalizer, LS Series

		Loss in dB at Frequency (MHz)											
Model Number/(P/N)	**Parameter**	**5–42**	**54**	**100**	**200**	**300**	**400**	**500**	**550**	**600**	**700**	**750**	**862**
LS-FEQR-750	Insertion Loss, dB	1.2	9.0	7.8	6.4	5.2	4.1	3.2	3.0	2.6	1.6	1.5	—
(PS0126)	Cable Equalizer, dB	—	—	—	—	5.6	—	—	7.9	—	—	9.0	—
[750 MHz]	Passband, Fwd/Rtn, MHz	54–750/5–42											
	Passband Flatness, dB	±0.25											
LS-FEQR-862	Insertion Loss, dB	1.2	10.0	8.5	7.2	6.1	5.2	4.3	3.9	3.4	2.7	2.3	1.8
(PS0125)	Cable Equalizer, dB	—	—	—	—	—	—	—	8.0	—	—	—	10.3
[862 MHz]	Passband, Fwd/Rtn, MHz	54–862/5–42											
	Passband Flatness, dB	±0.3											

Common Specifications

Impeadance, Ohms, All Ports	75
Return Loss, Input and Output, dB Min.	18
Power Passing, Amps Max.	15
Return PAD Model and Range	C-COR Model IPB-x Series, 0 to 22 dB range

Fiber Data

7.1 Fiber Optic Color Code

Individual fibers in a multi-fiber cable can be identified by an EIA/TIA-598 defined color code which is given in the table below.

EIA/TIA-598 Fiber Color Code

Number	Color	Number	Color
1	Blue	7	Red
2	Orange	8	Black
3	Green	9	Yellow
4	Brown	10	Violet
5	Slate	11	Rose
6	White	12	Aqua

7.2 Fiber Loss

CommScope Optical Reach® Fiber Cable Single Mode 1310/1550nm (9/125μm)

	Depressed	Matched Clad	Units
Max. Attenuation at 1310nm	0.35	0.35	dB/km
	0.56	0.56	dB/mi
	0.107	0.107	dB/1000 ft
at 1550nm	0.25	0.25	dB/km
	0.40	0.40	dB/mi
	0.076	0.076	dB/1000 ft
Max. Dispersion at 1285–1330nm	<2.8	<3.2	ps/nm·km
at 1550nm	18	18	ps/nm·km
Fusion splices[1]	0.05	0.05	dB/km
Mechanical splice[1]	0.15dB per splice		
Connector loss[1]	0.25dB per each super FC to PC connector set		
Sag and storage[1]	Add 4% to fiber length		

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[1] Typically accepted values.

Fiber Optic Cable Loss Characteristics

Path Length		1310nm (dB)			1550nm (dB)		
km	mi	Fiber Loss	with splices	with conn.	Fiber Loss	with splices	with conn.
1	0.6	0.35	0.40	0.90	0.25	0.30	0.80
2	1.2	0.70	0.80	1.30	0.50	0.60	1.10
3	1.9	1.05	1.20	1.70	0.75	0.90	1.40
4	2.5	1.40	1.60	2.10	1.00	1.20	1.70
5	3.1	1.75	2.00	2.50	1.25	1.50	2.00
6	3.7	2.10	2.40	2.90	1.50	1.80	2.30
7	4.3	2.45	2.80	3.30	1.75	2.10	2.60
8	5.0	2.80	3.20	3.70	2.00	2.40	2.90
9	5.6	3.15	3.60	4.10	2.25	2.70	3.20
10	6.2	3.50	4.00	4.50	2.50	3.00	3.50
20	12.4	7.00	8.00	8.50	5.00	6.00	6.50
30	18.6	10.50	12.00	12.50	7.50	9.00	9.50
40	24.9	14.00	16.00	16.50	10.00	12.00	12.50
50	31.1	17.50	20.00	20.50	12.50	15.00	15.50
60	37.3	21.00	24.00	24.50	15.00	18.00	18.50
70	43.4	24.50	28.00	28.50	17.50	21.00	21.50
80	49.7	28.00	32.00	32.50	20.00	24.00	24.50
90	55.9	31.50	36.00	36.50	22.50	27.00	27.50
100	62	35.00	40.00	40.50	25.00	30.00	30.50

7.3 Optical Connectors

Optical connector types (illustrated in the *Optical Connectors* figure on page 7-4) all come in APC (angled) and UPC (ultra-polished, flat) ends.

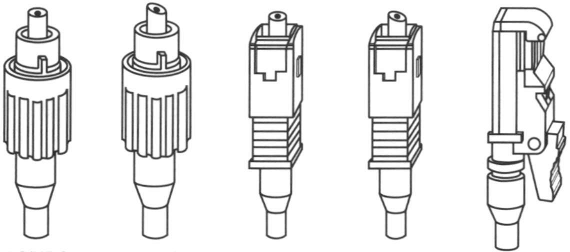
7.3.1 Color Coding

Although there is no official industry color code for SC connectors, there is a commonly-used color code to indicate APC/UPC type to ensure that fiber cable connectors are mated with the corresponding bulkhead connectors.
ANSI/TIA/EIA-568-A (TIA/EIA-568-A), “Commercial Building Telecommunications Cabling Standard,” specifies that SC/APC connectors are *green* and SC/UPC connectors are *blue*.

E2000 connectors follow the same color coding convention as SC connectors. E2000/APC connectors are *green*.

***Note**: Bulkhead connector adapters should also—but may not—follow this typical color coding.*

There is no industry color standard to distinguish FC/APC and FC/UPC connectors. FC connectors have a metal ferrule that is used to screw the connector into a metal FC adapter. The rubber boots at the base of these ferrules come in a variety of colors, but these colors typically vary from one vendor to another.



FC/UPC

FC/APC (angled tip)

SC/UPC (blue)

SC/APC (angled tip) (green)

E2000/APC (green)

Optical Connectors

CAUTION: U.S. manufactured APC optical connectors are angled at 8°. Some non-U.S. manufacturers make 9° APC connectors which will not mate with 8° connectors. The eye cannot distinguish between 8° and 9° angles, even when placed side by side. Check connector specifications.

7.3.2 Specifications

JDS Optical Connector Specifications

	FC/APC or SC/APC	FC/PC or SC/PC
Return Loss	60 dB min, 68 dB typ	50 dB min, 55 dB typ
Insertion Loss	0.15 dB typical, 0.30 dB maximum	
Mating Durability	200 matings, 25 cleanings	

7.4 Optical Attenuators

Optical attenuators are used to manage optical signals to multiple receivers which require different input levels. They are typically available in 1 dB steps from 1 dB to 30 dB, with either SC/APC, SC/UPC, FC/APC, FC/UPC, or E2000/APC connectors. They can be purchased as 1310 nm only, 1550 nm only, or 1310 and 1550 nm.

7.5 Optical Couplers and Splitters

An optical coupler is used to split an optical signal to multiple signals or to combine multiple signals into one signal. Optical couplers are typically defined by a percentage ratio at the output ports, instead of a dB loss value. The loss through a coupler port can be approximated by the following equation.

$$\textbf{Loss through Port A (dB)} = 10\log_{10}(\textbf{split ratio}) - \textbf{AL}$$

Where the split ratio is the percentage of signal through Port A. For example, if 75% of the signal passes through Port A the split ratio is 0.75. **AL** is the additional non-ideal coupler loss and is dependant on the manufacturer and the number of ports on the coupler. The following tables are for reference purposes only. Actual losses will vary between vendors.

C-COR 1 x n Optical Couplers

Split (%)	Typical Loss (dB)	Split (%)	Typical Loss (dB)
99	0.15	1	21.3
97	0.25	3	16.1
95	0.36	5	14.0
90	0.6	10	10.5
85	0.8	15	8.6
80	1.1	20	7.3
75	1.4	25	6.3
70	1.7	30	5.5
67	2.3	33	5.3
65	2.1	35	4.8
60	2.4	40	4.2
55	2.8	45	3.8
50	3.3	50	3.3

Typical Additional Loss (AL) per Number of Ports[1,2]

Number of Ports	Additional Loss (dB)	Number of Ports	Additional Loss (dB)
1 x 2	0.3	1 x 13	1.2
1 x 3	0.6	1 x 14	1.2
1 x 4	0.6	1 x 15	1.2
1 x 5	0.9	1 x 16	1.2
1 x 6	0.9	1 x 17	1.5
1 x 7	0.9	1 x 18	1.5
1 x 8	0.9	1 x 19	1.5
1 x 9	1.2	1 x 20	1.5
1 x 10	1.2	1 x 21	1.5
1 x 11	1.2	1 x 22	1.5
1 x 12	1.2		

1. Includes 0.3dB for connector loss.
2. Example: A 20% port on a 1 x 2 coupler has a typical loss of 7.6dB (7.3dB insertion loss + 0.3dB connector loss), while a 20% port on a 1 x 4 coupler has a typical loss of 7.9dB (7.3dB insertion loss + 0.6dB AL).

7.6 Wavelength Division Multiplexing (WDM)

Wavelength Division Multiplexing is the transmission of multiple optical signals on one fiber at different wavelengths, or channels. The signals are combined for transmission by a multiplexer (mux) and separated at the receiving end by a demultiplexer (demux).

***Note**: The Wavelength Division Multiplexing transmission process typically requires two WDMs—one to multiplex at the transmission end, and another to demultiplex at the receiving end.*

7.6.1 Coarse Wavelength Division Multiplexing Specifications

Coarse WDMs transmit two widely spaced wavelengths multiplexed onto one fiber.

Specifications for C-COR Coarse Wavelength Division Muliplexers (WDM)

Wavelengths	1310/1550nm
Bandpass	±15nm
Insertion Loss	0.6dB
Directivity	>55dB
Isolation	>35dB

7.7 Dense Wavelength Division Multiplexing (DWDM)

Dense WDMs use closely spaced wavelengths, making it possible to transmit multiple signals on the same fiber.

7.7.1 ITU-Grid Channels

ITU (International Telecommunications Union), headquartered in Geneva, Switzerland, is an international organization within which governments and the private sector coordinate global telecommunications networks and services. (For more information on ITU and its standards, go to www.itu.int.)

ITU channels consist of wavelengths ranging from 1517.94 to 1577.03 nm spaced in 100 GHz frequency steps. The 16 most commonly used wavelengths are split into two 8-channel ranges which are referred to as *red* and *blue*. *Red* refers to the eight lower frequency (longer wavelength) ITU odd-numbered channels 21 (1560.61 nm) to 35 (1549.32 nm). *Blue* refers to the eight higher frequency (shorter wavelength) ITU odd-numbered channels 43 (1542.94 nm) to 57 (1531.90 nm).

The following table provides the entire ITU Grid. Sections 7.7.2 through 7.7.6 provide specifications on C-COR DWDM multiplexers and demultiplexers based on the ITU Grid.

ITU-Grid Channels

Channel	Frequency (GHz)	Wavelength (nm)	Channel	Frequency (GHz)	Wavelength (nm)	Channel	Frequency (GHz)	Wavelength (nm)
1	190,100	1,577.03	26	192,600	1,556.56	51	195,100	1,536.61
2	190,200	1,576.20	27	192,700	1,555.75	52	195,200	1,535.82
3	190,300	1,575.37	28	192,800	1,554.94	53	195,300	1,535.04
4	190,400	1,574.54	29	192,900	1,554.13	54	195,400	1,534.25
5	190,500	1,573.71	30	193,000	1,553.33	55	195,500	1,533.47
6	190,600	1,572.89	31	193,100	1,552.52	56	195,600	1,532.68
7	190,700	1,572.06	32	193,200	1,551.72	57	195,700	1,531.90
8	190,800	1,571.24	33	193,300	1,550.92	58	195,800	1,531.12
9	190,900	1,570.42	34	193,400	1,550.12	59	195,900	1,530.33
10	191,000	1,569.59	35	193,500	1,549.32	60	196,000	1,529.55
11	191,100	1,568.77	36	193,600	1,548.51	61	196,100	1,528.77
12	191,200	1,567.95	37	193,700	1,547.72	62	196,200	1,527.99
13	191,300	1,567.13	38	193,800	1,546.92	63	196,300	1,527.22
14	191,400	1,566.31	39	193,900	1,546.12	64	196,400	1,526.44
15	191,500	1,565.50	40	194,000	1,545.32	65	196,500	1,525.66
16	191,600	1,564.68	41	194,100	1,544.53	66	196,600	1,524.89
17	191,700	1,563.86	42	194,200	1,543.73	67	196,700	1,524.11
18	191,800	1,563.05	43	194,300	1,542.94	68	196,800	1,523.34
19	191,900	1,562.23	44	194,400	1,542.14	69	196,900	1,522.56
20	192,000	1,561.42	45	194,500	1,541.35	70	197,000	1,521.79
21	192,100	1,560.61	46	194,600	1,540.56	71	197,100	1,521.02
22	192,200	1,559.79	47	194,700	1,539.77	72	197,200	1,520.25
23	192,300	1,558.98	48	194,800	1,538.98	73	197,300	1,519.48
24	192,400	1,558.17	49	194,900	1,538.19	74	197,400	1,518.71
25	192,500	1,557.36	50	195,000	1,537.40	75	197,500	1,517.94

7.7.2 Upgradable/Non-Upgradable DWDMs

Upgradable DWDMs provide an extra input or output port for the insertion and transmission of a second band of wavelengths to be combined and separated by another DWDM. For example, an 8-channel upgradable, red DWDM multiplexer provides a ninth input port for the multiplexed blue channels from the output of a blue band multiplexer. The corresponding (red, upgradable) demultiplexer provides a ninth output port for the multiplexed blue channels to be input to a blue band demultiplexer. See the following table for the wavelengths and band of the common ITU channel numbers.

Non-upgradable DWDMs have no extra inputs/outputs and are therefore limited to transmitting/receiving only the 4-channel or 8-channel band specified when ordered.

7.7.3 4-Channel Non-Upgradable DWDM Specifications

The 4-channel non-upgradable DWDM provides four ITU channels in a choice of four bands—red/high, red/low, blue/high, and blue/low, as indicated below.

C-COR 4-Channel Non-Upgradable DWDM[1]

ITU Channel Number	Center Wavelength (nm)	Band	Insertion Loss Typ/Max (dB) Mux	Demux	Total
21	1560.61	red/high	1.6/2.0	1.2/1.5	3.0/3.7
23	1558.98		1.3/1.6	1.5/1.9	
25	1557.38		1.0/1.2	1.8/2.3	
27	1555.75		1.0/1.2	1.8/2.3	
29	1554.13	red/low	1.6/2.0	1.2/1.5	3.0/3.7
31	1552.52		1.3/1.6	1.5/1.9	
33	1550.92		1.0/1.2	1.8/2.3	
35	1549.32		1.0/1.2	1.8/2.3	
43	1542.94	blue/high	1.6/2.0	1.2/1.5	3.0/3.7
45	1541.35		1.3/1.6	1.5/1.9	
47	1539.77		1.0/1.2	1.8/2.3	
49	1538.19		1.0/1.2	1.8/2.3	
51	1536.61	blue/low	1.6/2.0	1.2/1.5	3.0/3.7
53	1535.04		1.3/1.6	1.5/1.9	
55	1533.47		1.0/1.2	1.8/2.3	
57	1531.90		1.0/1.2	1.8/2.3	

[1] Blue channel options also include blue/high channels 45 to 51 and blue/low channels 53 to 59 (1530.33nm).

7.7.4 8-Channel Non-Upgradable DWDM Specifications

The 8-channel, non-upgradable DWDM provides eight ITU channels in either the red band (ITU channels 21 to 35), or the blue band (ITU channels 43 to 57), as indicated below.

C-COR 8-Channel Non-Upgradable DWDM

ITU Channel Number	Center Wavelength (nm)	Band	Insertion Loss Typ/Max (dB)		
			Mux	Demux	Total
21	1560.61	red	2.9/3.6	1.2/1.5	4.4/5.5
23	1558.98		2.5/3.2	1.6/1.9	
25	1557.38		2.2/2.8	1.9/2.3	
27	1555.75		2.2/2.8	2.1/2.7	
29	1554.13		1.9/2.4	2.5/3.1	
31	1552.52		1.6/2.0	2.8/3.5	
33	1550.92		1.2/1.6	3.1/3.9	
35	1549.32		1.0/1.2	3.1/3.9	
43	1542.94	blue	2.9/3.6	1.2/1.5	4.4/5.5
45	1541.35		2.5/3.2	1.6/1.9	
47	1539.77		2.2/2.8	1.9/2.3	
49	1538.19		2.2/2.8	2.1/2.7	
51	1536.61		1.9/2.4	2.5/3.1	
53	1535.04		1.6/2.0	2.8/3.5	
55	1533.47		1.2/1.6	3.1/3.9	
57	1531.90		1.0/1.2	3.1/3.9	

7.7.5 8-Channel Upgradable DWDM Specifications

The 8-channel upgradable DWDM mux is a red band mux (8RU—8-channel, red, upgradable) with a ninth input port to accommodate the input of the muxed output from an 8-channel, non-upgradable, blue band DWDM mux (8B). The two muxes combined provide inputs for 16 optic channels.

At the receiving end, the upgradable DWDM demux is a red band demux (8RU) with a ninth output port for the muxed blue band channels to be input to a non-upgradable, blue band demux (8B). The two demuxes combined provide output for 16 optic channels.

The red band insertion losses shown below are for the C-COR upgradable red mux/demux (8RU). The blue band losses are for the upgradable red band mux/demux coupled with the blue band, non-upgradable mux/demux (8RU + 8B).

C-COR 8/16-Channel Upgradable DWDM

ITU Channel Number	Center Wavelength (nm)	Band	Insertion Loss Typ/Max (dB)		
			Mux	Demux	Total
21	1560.61	red	3.6/4.6	2.0/2.5	6.0/7.5
23	1558.98		3.3/4.2	2.3/2.8	
25	1557.38		3.0/3.8	2.6/3.3	
27	1555.75		3.0/3.8	3.0/3.7	
29	1554.13		2.7/3.4	3.3/4.1	
31	1552.52		2.4/3.0	3.6/4.5	
33	1550.92		2.0/2.6	4.0/4.9	
35	1549.32		1.8/2.2	4.0/4.9	
43	1542.94	blue	3.6/4.6	2.0/2.5	6.0/7.5
45	1541.35		3.3/4.2	2.3/2.8	
47	1539.77		3.0/3.8	2.6/3.3	
49	1538.19		3.0/3.8	3.0/3.7	
51	1536.61		2.7/3.4	3.3/4.1	
53	1535.04		2.4/3.0	3.6/4.5	
55	1533.47		2.0/2.6	4.0/4.9	
57	1531.90		1.8/2.2	4.0/4.9	

7.7.6 16-Channel DWDM Specifications

The 16-channel DWDM mux provides inputs for the 8 red channels, 21 through 35, and 8 blue channels, either 43 through 57 or 45 through 59.

At the receiving end, the DWDM demux provides outputs for 16 optic channels.

Insertion losses for the C-COR 16-channel DWDM are shown below.

C-COR 16-Channel DWDM[1]

ITU Channel Number	Center Wavelength (nm)	Band	Insertion Loss Typ/Max (dB)		
			Mux	Demux	Total
21	1560.61	red	3.6/4.6	2.0/2.5	6.0/7.5
23	1558.98		3.3/4.2	2.3/2.8	
25	1557.38		3.0/3.8	2.6/3.3	
27	1555.75		3.0/3.8	3.0/3.7	
29	1554.13		2.7/3.4	3.3/4.1	
31	1552.52		2.4/3.0	3.6/4.5	
33	1550.92		2.0/2.6	4.0/4.9	
35	1549.32		1.8/2.2	4.0/4.9	
43	1542.94	blue	3.3/4.2	2.0/2.5	6.0/7.5
45	1541.35		3.0/3.8	2.3/2.9	
47	1539.77		2.7/3.4	2.6/3.3	
49	1538.19		2.7/3.4	3.0/3.7	
51	1536.61		2.4/3.0	3.3/4.1	
53	1535.04		2.0/2.6	3.6/4.5	
55	1533.47		1.7/2.2	4.0/4.9	
57	1531.90		1.4/1.8	4.0/4.9	

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[1] Blue channel options also include channels 45 to 59 (1530.33 nm).

7.8 Optical Modulation Index (OMI)

Optical Modulation Index is a measurement of the intensity of modulation on an optical transmitter. OMI is defined as a ratio of the normal operational level(s) versus the level required to saturate (clip) the device. It can be referred to in terms of per-channel OMI, composite (or RMS) OMI, and maximum instantaneous OMI.

Per channel OMI is defined as a ratio of the normal per channel operational input level of the device versus the input level of a single carrier required to cause clipping in the same device. It can be determined from the following equation.

$$\mathbf{OMI_{PC} = 10^{\frac{(V_{TX} - V_{SAT})}{20}} \bullet 100}$$

Where OMI_{PC} = Per channel Optical Modulation Index (%)
V_{TX} = Per carrier Tx input at normal operating level (dBmV)
V_{SAT} = Tx input level of one carrier at sauration level (dBmV)

Root-Mean-Squared (RMS) OMI, which is commonly referred to as Composite OMI, is a method of measuring the average total OMI on a transmitter when it is carrying multiple carriers. It can be determined from the following equation.

$$\mathbf{OMI_{RMS} = \sqrt{\frac{N}{2}} \bullet OMI_{PC}}$$

Where OMI_{RMS} = Root-Mean Squared Modulation Index (%)
N = Number of Carriers at Tx input
OMI_{PC} = Per channel Optical Modulation Index (%)

Maximum instantaneous OMI is a method of measuring the maximum possible total OMI on a transmitter when it is carrying multiple carriers. OMI_{MI} occurs only when all the carriers reach their peak voltage at the same instant, and can be determined from the following equation.

$$\mathrm{OMI}_{MI} = N \bullet \mathrm{OMI}_{PC}$$

Where OMI_{MI} = Maximum Instantaneous OMI (%)

N = Number of Carriers at Tx input

OMI_{PC} = Per channel Optical Modulation Index (%)

Note: Typical forward path transmitters have the capability of carrying 80 analog carriers at a per-channel OMI (OMI_{PC}) of 3.5%. Using the previous equations, the root-mean-squared OMI (OMI_{RMS}) is approximately 22%, but the maximum instantaneous OMI (OMI_{MI}) is 280%. What this means is that while the average OMI is 22%, the instantaneous OMI can be significantly greater than the clipping point of the laser (100%). Although it is beyond the scope of this guide, statistical models have shown that instantaneous OMI can be kept below 100% if OMI_{RMS} is kept below 25%. See additional equations below.

7.8.1 Additional Useful OMI Equations

The maximum transmitter drive level that will keep the Composite OMI (OMI_{RMS}) below 25% can be determined by the following equation.

$$V_{MAX} = V_{REF} - 20 \bullet \log\left(\sqrt{8 \bullet N} \bullet \frac{\mathrm{OMI}_{PC-REF}}{100}\right)$$

Where V_{MAX} = Tx input that will keep $\mathrm{OMI}_{RMS} < 25\%$ (dBmV)

V_{REF} = Reference Level at Tx input (dBmV)

N = Number of Carriers at Tx input

OMI_{PC-REF} = Reference Per channel OMI (%)

The RF output of a receiver is related to the OMI by the following equation.

$$V_{RX} = 2 \bullet P_{in} + 20 \bullet \log\left(\frac{OMI_{PC}}{100}\right) + R_{RX} + 34.5$$

Where V_{RX} = Level at Rx output (dBmV)

P_{in} = Optical input power (dBm)

OMI_{PC} = Per channel OMI (%)

R_{RX} = Optical Receiver Responsivity (dB A/W)

$$R_{RX}\left(dB\frac{A}{W}\right) = 20 \bullet \log\left[R_{RX}\left(\frac{A}{W}\right)\right]$$

The change in receiver output is related to a change in OMI by the following equation.

$$V_2 = 20 \bullet \log\left(\frac{OMI_{PC-2}}{OMI_{PC-REF}}\right) + V_{REF}$$

Where V_2 = New level at Rx output (dBmV)

V_{REF} = Reference level at Rx output (dBmV)

OMI_{PC-2} = New per channel OMI (%)

OMI_{PC-REF} = Reference per channel OMI (%)

The change in transmitter OMI is related to a change in drive level by the following equation.

$$OMI_{PC-2} = 10^{\left(\frac{V_2 - V_{REF}}{20}\right)} + OMI_{PC-REF}$$

Where V_2 = New level at Tx input (dBmV)

V_{REF} = Reference level at Tx input (dBmV)

OMI_{PC-2} = New per channel OMI (%)

OMI_{PC-REF} = Reference per channel OMI (%)

7.9 dBm Conversions

dBm	mW	mV[1]	dBmV[1]
-13	0.05	61.31	35.75
-12	0.06	68.79	36.75
-11	0.08	77.18	37.75
-10	0.10	86.60	38.75
-9	0.13	97.16	39.75
-8	0.16	109.02	40.75
-7	0.20	122.32	41.75
-6	0.25	137.25	42.75
-5	0.32	153.99	43.75
-4	0.40	172.78	44.75
-3	0.50	193.87	45.75
-2	0.63	217.52	46.75
-1	0.79	244.06	47.75
0	1.00	273.84	48.75
1	1.26	307.26	49.75
2	1.58	344.75	50.75
3	2.00	386.81	51.75
4	2.51	434.01	52.75
5	3.16	486.97	53.75
6	3.98	546.39	54.75
7	5.01	613.06	55.75
8	6.31	687.86	56.75
9	7.94	771.79	57.75
10	10.00	865.96	58.75
11	12.59	971.63	59.75

[1] Assumes a 75Ω system.

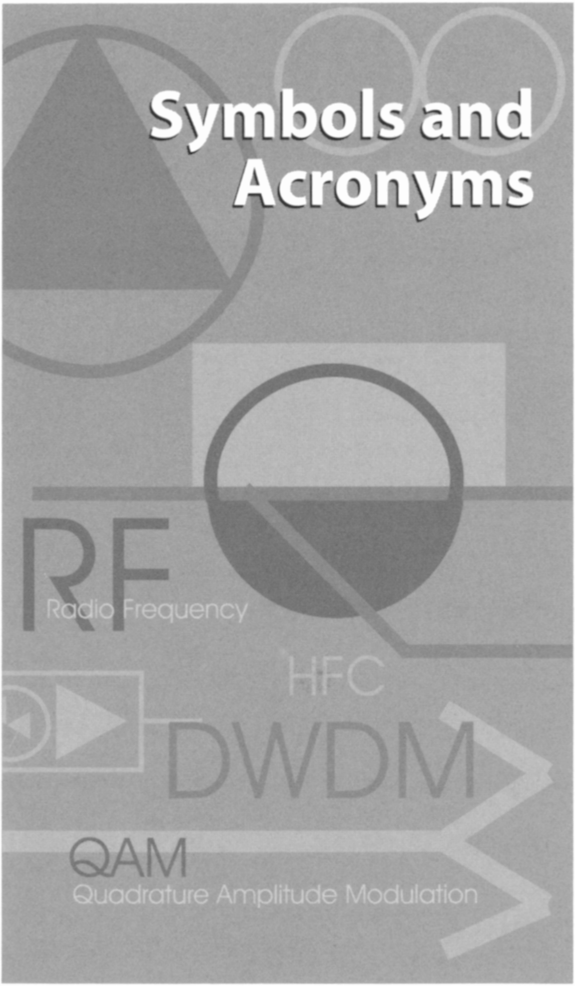
mW - dBm Conversion Equation

10 log (value in mW) = value in dBm

dBm to dBmV Conversion Equation

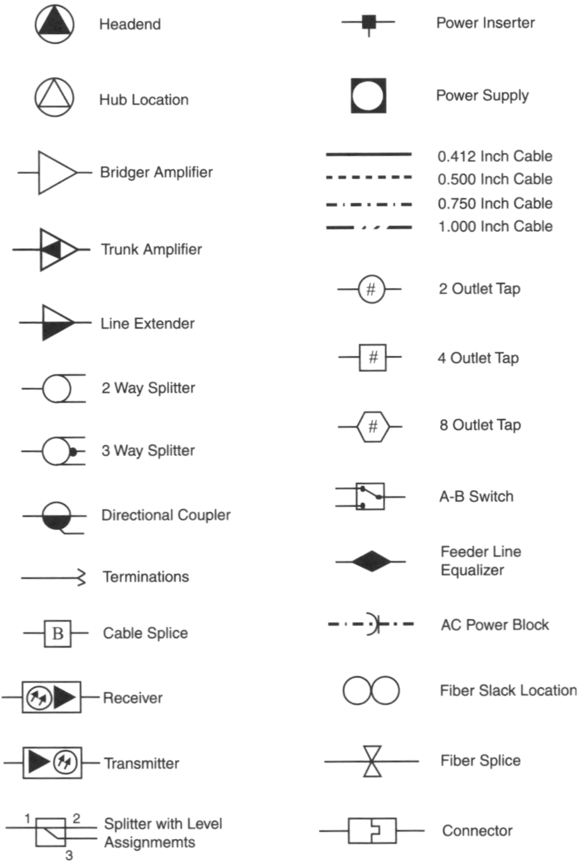
Value in dBmV = Value in dBm + 48.75

Symbols and Acronyms


RF
Radio Frequency
HFC
DWDM
QAM
Quadrature Amplitude Modulation

8.1 Common CATV Symbols

Below are typical cable system map symbols. Most cable system operators use their own versions of these symbols, so use the chart below as a general guideline.


Headend
Hub Location
Bridger Amplifier
Trunk Amplifier
Line Extender
2 Way Splitter
3 Way Splitter
Directional Coupler
Terminations
B
Cable Splice
Receiver
Transmitter
1
2
3
Splitter with Level Assignmemts
Power Inserter
Power Supply
0.412 Inch Cable
0.500 Inch Cable
0.750 Inch Cable
1.000 Inch Cable
#
2 Outlet Tap
#
4 Outlet Tap
#
8 Outlet Tap
A-B Switch
Feeder Line Equalizer
AC Power Block
Fiber Slack Location
Fiber Splice
Connector

8.2 Common Industry Acronyms

Acronym	Definition
AC	Alternating Current, Access Conditions, Access Customer, Area Code
ACD	Automatic Call Distributor
ADC, A/D	Analog to Digital Converter
ADPCM	Adaptive Differential Pulse Code Modulation
AFC	Automatic Frequency Control, Antenna for Communications
AFT	Automatic Fine Tuning
AGC	Automatic Gain Control
ALC	Automatic Level Control, ATM Link Controller
ALSC	Automatic Level and Slope Control
AM	Amplitude Modulation
AM-VSB	Amplitude Modulation - Vestigial Side Band
ANI	Automatic Number Identification
ANSI	American National Standards Institute
ARRL	American Radio Relay League
ARU	Audio Response Unit
ASC	Automatic Slope Control
ASCII	American Standard Code for Information Interchange
ASK	Amplitude Shifting Key
ATM	Asynchronous Transfer Mode
BASIC	Beginner's All-purpose Symbolic Instruction Code
BCT/E	Broadband Communications Technician/Engineer
BER	Bit Error Rate
BERT	Bit Error Rate Tester
BPF	Bandpass Filter
bps	Bits Per Second
BPSK	Binary Phase Shift Keying
BTSC	Broadcast Television Standards Committee
CAD	Computer Aided Design
CAN	Cable Area Network
CARS	Community Antenna Radio Service
CATV	Community Antenna Television, Cable Television

Acronym	Definition
CB	Citizens Band Radio
CCITT	Comite Consulttatif Internationale de Telegraphique et Telephique (see also ITU)
CDMA	Code Division Multiple Access
CE	Consumer Electronics
CLEC	Competitive Local Exchange Carrier
CLI	Cumulative Leakage Index
CM	Cable Modem, Computer Modem, Control Memory, Configuration Management
CMTS	Cable Modem Termination System, Computer Modem Termination System
CNM	Cable Network Manager
CNR, C/N	Carrier to Noise Ratio
CO	Central Office
CODEC	Coder/Decoder
CoS	Class of Service
CPD	Common Path Distortion
CPE	Customer Premises Equipment
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
CRT	Cathode Ray Tube
CSO	Composite Second Order
CSR	Customer Service Representative
CTB	Composite Triple Beat
CW	Continuous Wave, Carrier Wave
DAC, D/A	Digital to Analog Converter
dB	Decibel
dBc	Decibel relative to carrier
dBm	Decibel relative to milliwatt
dBmV	Decibel relative to millivolt
DBS	Digital Broadcasting Satellite, Digital Broadcast Service, Direct Broadcast Satellite
DC	Direct Current
DCE	Data Communications Equipment, Data Circuit-terminating Equipment

Acronym	Definition
DEMUX	Demultiplexer
DFB	Distributed Feedback
DMA	Direct Memory Access
DOCSIS	Data-Over-Cable Service Interface Specification
DRAM	Digital Recorded Announcement Machine, Dynamic Random Access Memory
DS	Digital Signal, Digital Service, Downstream
DSL	Digital Subscriber Line
DTE	Data Terminal Equipment
DTMF	Dial Tone Multi-frequency
DVB	Digital Video Broadcast
DWDM	Dense Wavelength Division Multiplexing
EDFA	Erbium Doped Fiber Amplifier
EEPROM	Electrically Erasable Programmable Read Only Memory
EIA	Electronic Industries Association
EISA	Extended Industry Standard Architecture
EMI	Electromagnetic Interference
EMS	Element Management System
EO	End Office (exchange)
EOL	End of Line
EPROM	Erasable Programmable Read Only Memory
ESD	Electrostatic Discharge
FCC	Federal Communications Commission
FDM	Frequency Division Multiplex
FDMA	Frequency Division Multiple Access
FEC	Forward Error Correction
FIFO	First In, First Out
FM	Frequency Modulation
FN	Fiber Node
FP	Fabry-Perot
FPGA	Field Programmable Gate Array
FSK	Frequency Shift Keying
FTP	File Transfer Protocol

Acronym	Definition
FTTC	Fiber to the Curb
FTTF	Fiber to the Feeder
FTTH	Fiber to the Home
GB	Gigabyte (one billion bytes)
GaAs	Gallium Arsenide
Gbps	Giga (1000 million) Bits Per Second
GBps	Giga (1000 million) Bytes Per Second
GHz	Gigahertz
GPS	Global Positioning Satellite
GUI	Graphical User Interface
HD	High Definition
HDT	Host Digital Terminal
HDTV	High Definition Television
HFC	Hybrid Fiber/Coax
HITS	Headend In The Sky
HPF	High Pass Filter
HRC	Harmonically Related Carrier
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
Hz	Hertz
I/O	Input/Output
IC	Integrated Circuit, Inter-exchange Carrier
IEEE	Institute of Electrical and Electronics Engineers
IF	Intermediate Frequency
IM	Intermodulation
I-Net	Institutional Network
IP	Internet Protocol
IPPV	Impulse Pay Per View
I/Q	In-Phase Quadrature
IR	Infrared, Infrared Remote
IRD	Integrated Receiver/Decoder
ISDN	Integrated Services Digital Network
ISO	International Standards Organization
IT	Information Technology

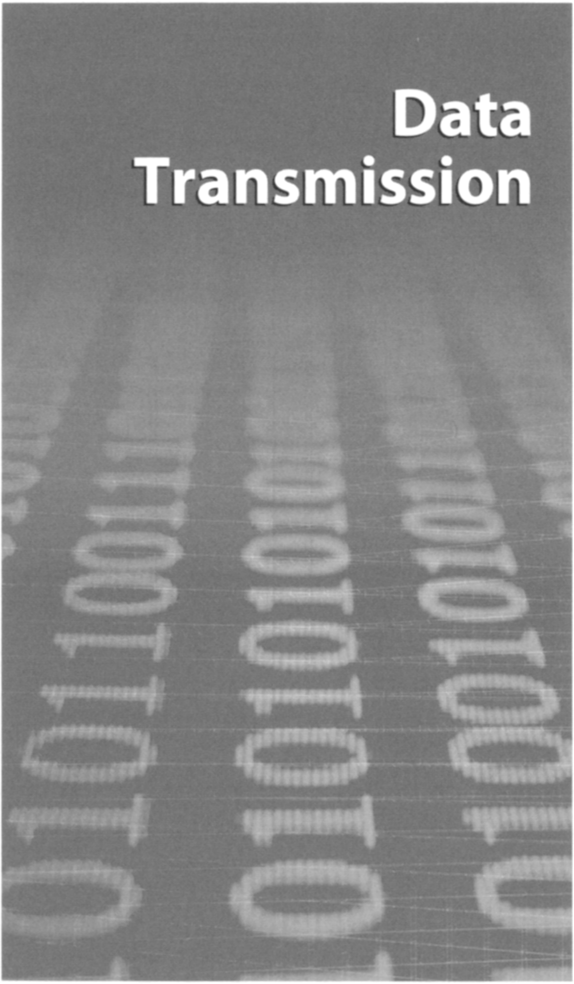
Acronym	Definition
ITU	International Telecommunication Union
kbps	Kilobits Per Second
kHz	Kilohertz
LAN	Local Area Network
LCD	Liquid Crystal Display
LEC	Local Exchange Carrier, LAN Emulator Client
LED	Light Emitting Diode
LFD	Low Frequency Distortion
LNA	Low Noise Amplifier
LNB, LNC	Low Noise Block Converter
LO	Local Origination, Local Oscillator
LOS	Line of Sight, Loss of Optical Signal
LPF	Low Pass Filter
LSb	Least Significant Bit
LSB	Least Significant Byte
MAC	Media Access Control
MATV	Master Antenna TV System
Mb	Megabit (one million bits)
MB	Megabyte (one million bytes)
Mbps	Megabits Per Second
MBps	Megabytes Per Second
MDU	Multiple Dwelling Unit
MER	Modulation Error Ratio
MF	Multifrequency
MHz	Megahertz
MIPS	Million Instructions Per Second
MMDS	Multichannel Multipoint Distribution Service, Microwave Multipoint Distribution System
MODEM	Modulator/Demodulator
MPEG	Moving Pictures Expert Group
MSb	Most Significant Bit
MSB	Most Significant Byte
MSO	Multiple System Operator
MTBF	Mean Time Between Failure

Acronym	Definition
MTS	Modem Termination System, MPEG Transport Stream, Multichannel TV Sound
MTTF	Mean Time to Failure
MTTR	Mean Time to Repair
MUX	Multiplexer
mW	Milli-Watt
NCTA	National Cable and Telecommunication Association
NCTI	National Cable Television Institute
NEC	National Electrical Code
NESC	National Electrical Safety Code
NIC	Network Interface Card
NML	Network Management Layer
NMS	Network Management System
NOC	Network Operations Center
NPR	Noise Power Ratio
NTSC	National Television System Committee (US)
NVOD	Near Video On Demand
OC	Optical Carrier
OMI	Optical Modulation Index
OS	Operating System
OSD	On-screen Display
OTDR	Optical Time Domain Reflectometer
PAL	Phase Alternation by Line (European 50 Hz analog TV standard)
PAM	Pulse Amplitude Modulation
PC	Personal Computer
PCB	Printed Circuit Board
PCM	Pulse Code Modulation
PCMCIA	Personal Computer Memory Card International Assn.
PCS	Personal Communications Services
PIN	Personal Identification Number
PLL	Phase Locked Loop
POP	Proof of Performance, Point of Presence
POTS	Plain Old Telephone Service

Acronym	Definition
PPV	Pay Per View
PS	Power Supply
PSK	Phase Shift Keying
PSTN	Public Switched Telephone Network
PVC	Polyvinyl Chloride
QAM	Quadrature Amplitude Modulation
QOS	Quality of Service
QPSK	Quadrature Phase Shift Key
RAID	Redundant Array of Independent Discs
RAM	Random Access Memory
RF	Radio Frequency
RFI	Radio Frequency Interference
RL	Return Loss
RMS	Root Mean Square
ROM	Read Only Memory
SAP	Secondary Audio Program, Service Access Point, Service Advertisement Protocol
S-CDMA	Synchronous Code Division Multiple Access
SCSI	Small Computer System Interface
SCTE	Society of Cable Telecommunications Engineers
SDH	Synchronous Digital Hierarchy
SECAM	Système Électronique pour Couleur Avec Memoire (European TV)
SMATV	Satellite Master Antenna Televisions System
SNMP	Simple Network Management Protocol
SNR, S/N	Signal to Noise Ratio
SONET	Synchronous Optical Network
SS7	Signaling System 7, Switching System 7
SSB	Single Side Band, Star Star Bus
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
TDM	Time Division Multiplex
TDMA	Time Division Multiple Access
TDR	Time Domain Reflectometer

Acronym	Definition
TL	Transfer Linearization
TVRO	Television Receive Only Earth Station
UHF	Ultra-High Frequency
UI	User Interface
UPS	Uninterruptable Power Supply, Universal Power Supply
URL	Uniform Resource Locator
USB	Universal Serial Bus
US	Upstream
VBI	Vertical Blanking Interval
VCR	Video Cassette Recorder
VF	Voice Frequency
VHF	Very High Frequency
VHS	Video Home System
VIRS	Vertical Interval Reference Signal
VITS	Vertical Interval Test Signal
VOD	Video On Demand
VoIP	Voice over Internet Protocol
VOIP	Voice On Internet Protocol
VOP	Velocity of Propagation
VPN	Virtual Private Network
VSB	Vestigial Sideband Modulation
VT	Virtual Tributary (SONET)
WAN	Wide Area Network
WDM	Wavelength Division Multiplexing
WWW	World Wide Web
XMOD/ XM	Cross Modulation

Data Transmission



9.1 Digitizing an Analog Signal

An analog signal is a continuously varying signal, like a sine wave. This signal varies over time, and has an infinite number of points during its cycle. The magnitude of the signal at any given point in time is called its amplitude, which varies smoothly in time.

In a broadband network, the baseband signal to be transmitted—typically in frequency or amplitude—in either direction away from the center or reference. Changing the frequency is referred to as Frequency Modulation (FM), and changing the amplitude is referred to as Amplitude Modulation (AM). When the altered analog signal reaches its destination, the receiver compares the signal to the reference and derives the desired signal information from the comparison.

A digital signal in its simplest form is information coded into binary bits, or 1s and 0s. To transmit an analog signal digitally, the digital signal must be sampled, quantized, and encoded.

9.1.1 Sampling and Quantizing

Sampling is when the amplitude of a signal is determined at fixed points in time. The maximum frequency of the analog signal determines the sampling rate. The sampling rate must always be at least two times the frequency that is being digitized—this is referred to as the Nyquist Sampling Theorem. Sampled analog amplitudes are then quantized.

Quantizing is the process of recording each sample as a number corresponding to the amplitude of the signal at that time. Sampling and quantizing determine how well the analog signal is represented digitally. Information in the analog signal is permanently lost during these processes, but increasing the sampling rate can minimize this loss. The accuracy of the digitizing process is determined by two factors:

- frequency of the sampling
- number of binary bits used to express the amplitudes.

The digitizing process and how the reconstruction of the analog signal is affected by sampling rate is illustrated in the *Low vs. High Sampling Rates* table on the following page.

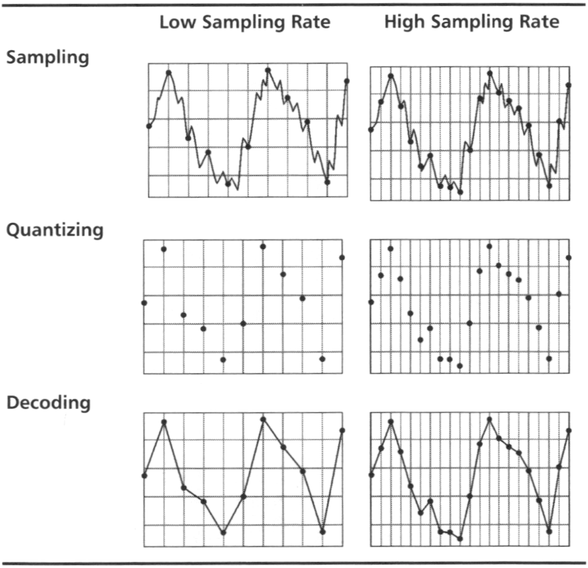
9.1.2 Encoding

Quantized samples are encoded into binary data or bits that can be stored or transmitted. The greater the number of bits used to represent the amplitudes of the analog signal, the more precisely the digital representation of the analog signal can be reconstructed into the original signal. The number of values required to adequately quantize an analog waveform dictates how many bits are required to encode the signal.

9.1.3 Decoding

At the receive end, the bits are interpreted and used to reconstruct the analog signal.

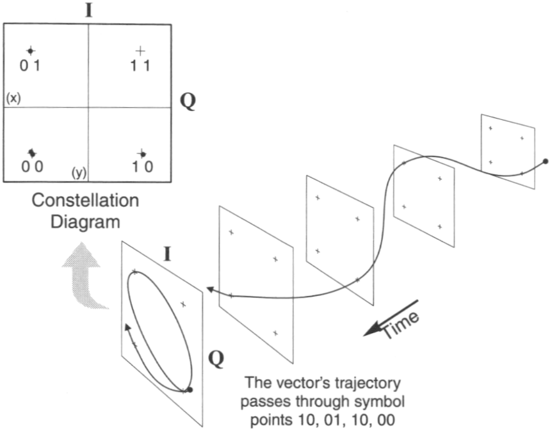
Low vs. High Sampling Rates


Low Sampling Rate
High Sampling Rate
Sampling
Quantizing
Decoding

9.2 QAM Transmission Basics

Quadrature Amplitude Modulation is a technique for transmitting digital data as an analog signal. This is accomplished by using a carrier wave split into two carriers of identical frequency, shifted 90° apart, each modulated to one of two or more possible discrete amplitude levels. Each combination of amplitude levels on the two carriers translates to a binary bit pattern.

I and **Q components** are two halves of a digital data bit pattern transmitted simultaneously, as voltage levels of two identical frequency carriers phase shifted 90° apart. The **I** (incidence or in-phase) component modulates (is transmitted on) the carrier in phase with the clock (unshifted). The **Q** (quadrature) component modulates the carrier phase-shifted 90° from the clock. See the *QPSK Constellation Diagram Showing I/Q Vector* figure.


I
0 1
1 1
(x)
Q
0 0
(y)
1 0
Constellation Diagram
I
Q
Time
The vector's trajectory passes through symbol points 10, 01, 10, 00

QPSK Constellation Diagram Showing I/Q Vector

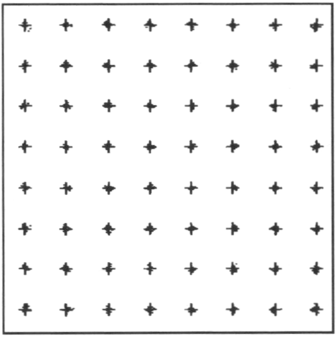
QPSK (Quadrature Phase Shift Keying) is the simplest form of QAM (also known as, 4-QAM). QPSK uses two carriers with identical frequency, phase shifted 90° apart, and two possible amplitude levels. One amplitude level represents a 0, the other a 1. See *QPSK Constellation Diagram Showing I/Q Vector* figure.

Bandwidth as Related to Bits per Symbol and Bit Rate

Modulation Format	Bits per Symbol	Bit Rate	Bandwidth (Symbol Rate)	Total Bandwidth (Including Guardbands)
QPSK	2	256kbps	128kHz	200kHz
QPSK	2	2Mbps	1MHz	1.25MHz
QPSK	2	10Mbps	5MHz	6MHz
8-VSB (US)	3	15Mbps	5MHz	6MHz
16-VSB (US)	4	20Mbps	5MHz	6MHz
16-QAM	4	20Mbps	5MHz	6MHz
32-QAM	5	25Mbps	5MHz	6MHz
64-QAM	6	30Mbps	5MHz	6MHz
256-QAM	8	40Mbps	5MHz	6MHz

Constellation Diagram is a map, or rectangular array, on which the received amplitude level of the **I** and **Q** QAM signal components are displayed as data points on an **I** x **Q** rectangular coordinate system. **I** components determine the horizontal position, and **Q** components determine the vertical position, of each data point. See the *Normal 64-QAM Constellation Diagram* figure. The constellation diagram is the matrix formed by horizontal and vertical lines (whether shown or imagined) between the possible **I** and **Q** component values. The digital value of each received data point is determined by which cell it falls into in the matrix. An error occurs if a data point falls outside its cell.

A 16-QAM diagram is a four-by-four array matrix with each of 16 cells representing one of the 16 possible binary combinations. The vertical and horizontal position of each dot corresponds to the **I** and **Q** amplitude levels of the signal transmitted in one cycle. See the *Normal 64-QAM Constellation Diagram* figure for a 64-QAM constellation diagram.

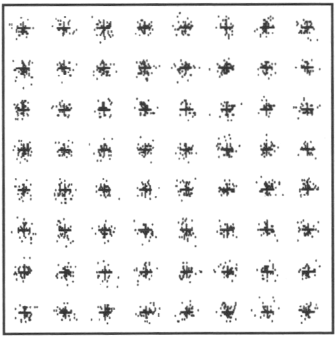


Normal 64-QAM Constellation Diagram

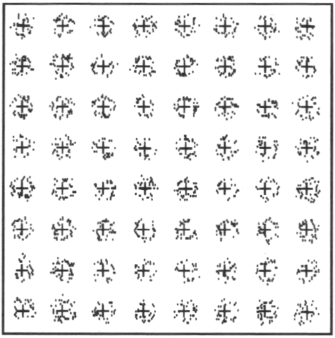
9.3 QAM Constellation Diagram Analysis

The patterns of dots in the constellation diagram cells can give some clues to transmission issues. Following is a list of common patterns and their typical diagnosis.

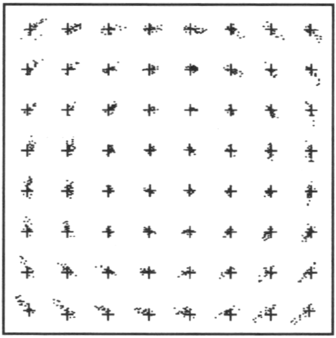
Poor CNR—picture will be perfect but slight further degradation will bring total failure. Fuzzy circular pattern in each cell will occupy most of the cell.



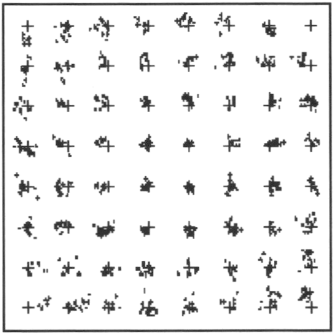
Ingress, CTB/CSO, or spurs—caused by coherent noise; will cause circular patterns in each cell.



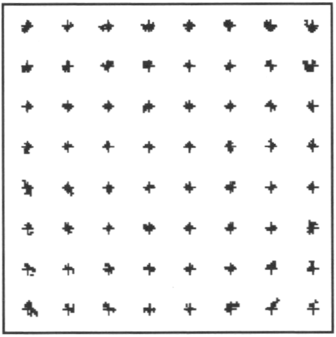
Phase-shift—caused by residual FM, normally a headend problem. Circular effect where points in each cell are stretched out perpendicular to a radius line, in proportion to the distance from the center of the diagram, giving an overall appearance of circles around the center of the diagram.



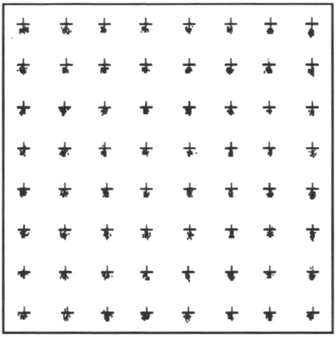
Gain compression—caused by IF and RF amplifiers and filters, up/down converters, or IF equalizers. Points pushed toward the I and Q axes in proportion to the distance from the center gives the outer boundary of the point pattern a rounded shape.



I Q imbalance—caused by problems with baseband amplifiers, filters, or the digital modulator, normally a headend problem. Overall pattern will appear taller than wide, or vice versa.

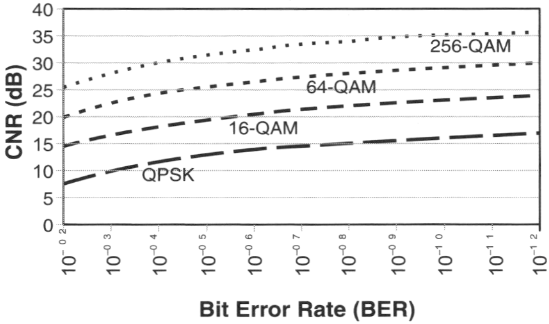


Carrier leakage (constellation offset)—caused by imbalance in the modulator's mixer or undesirable DC in the transmission system. Entire constellation is offset in one direction.



9.3.1 Transmission Speed vs. Noise

The benefit from higher QAM numbers is increased data transmission, since more data bits can be carried in each data cycle. At the same time, however, more data bits per cycle require more amplitude levels spaced closer together, making discrimination of the proper amplitude level more critical and subject to noise. Therefore, higher QAM numbers require correspondingly higher CNR performance to maintain a given allowable Bit Error Rate (BER). See the *CNR in Relation to BER* figure.



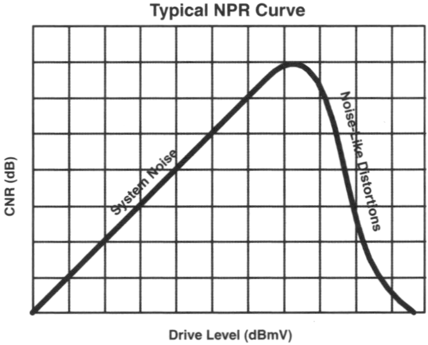
CNR in Relation to BER

9.4 BER, FEC, MER

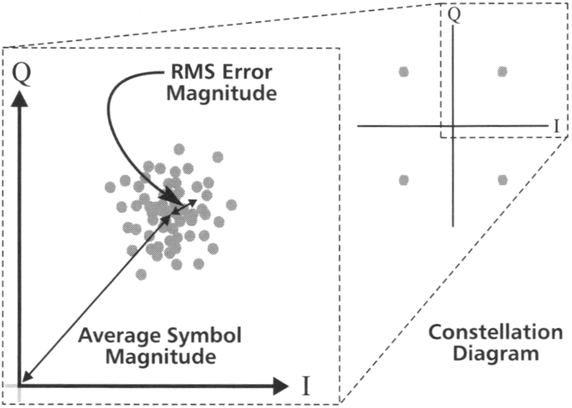
BER (Bit Error Rate) is a measurement of the number of bits incorrectly received. Specifically, BER is the number of bit errors divided by the total number of transmitted bits. This can be expressed in dB, but is usually in a 10^{-x} format. For example, 10^{-9} represents 1 bit received in error out of 1 billion transmitted bits.

NPR (Noise Power Ratio) is a measurement technique used to determine the signal-to-noise performance of an analog device that has been loaded with multiple QAM or QPSK signals. Since QAM and QPSK signals have a frequency spectrum similar to Gaussian noise, the NPR test is accomplished by replacing the signals with an equivalent band of white noise. Toward the middle of the band, a "notch" of noise (typically 4 MHz) is omitted.

When the band of noise is placed through a device, the depth of the notch will be limited by several factors. At low drive levels, the notch depth will be limited by system noise products such as Shot noise or Thermal noise. As the drive level is increased, the notch depth will increase 1 dB for every 1 dB of additional drive level until the device begins to enter compression. When the device enters compression, the notch will begin to fill with "noise-like" distortion products. Once compression is reached, the depth of the notch will typically decrease 5 dB for every 1 dB of additional drive level. NPR is occasionally referred to as the "Noise-in-the-Notch" test.



FEC (Forward Error Correction) is a programmed technique for identifying and correcting bit errors that occur in digital transmission. It is complex and processor intense, but necessary to prevent bit errors—which cannot be completely eliminated—from resulting in erroneous data or degraded picture quality.



MER Representation

MER (Modulation Error Ratio) is a measure of the deviation between the received value of the modulation (amplitude and/or phase) from the transmitted value. It is a figure of merit for modulation quality, much as is CNR for analog TV. Both are measured in dB, but for MER, smaller is better, while for CNR, larger is better.

The effect of MER can be seen on a constellation diagram (see the *MER Representation* figure) by the tightness of the dot pattern within each cell. As MER increases to the point where dots on the constellation diagram fall on or over cell boundaries, BER will begin to increase rapidly. When the BER overcomes the FEC's capacity to correct the bit errors, transmission failure occurs suddenly. Almost to the point of failure, the data/picture quality can be excellent, giving no clue to the proximity of failure. This is known as the "cliff effect," where everything is fine, no matter how close to the edge, until you go over. The additional complication with digital transmission is, if you are just looking at the picture, you don't know where the edge is.

9.4.1 DOCSIS

DOCSIS, or Data Over Cable Service Interface Specifications, was developed out of the need for standards resulting from the personal computing explosion of the 1980s. As the awareness of the Internet increased, the demand for high-speed, high-quality data service also increased. With its inherent two-way signal capability, cable evolved into a hybrid digital and analog transmission system to accommodate the increasing demand for applications such as telephony and advanced video services. In 1995, a consortium of MSOs (Multiple System Operator) and cable manufacturers assembled to develop standards to create an open market for cable modems, ultimately enabling end-users to purchase the products of their choice. Today, DOCSIS is the dominant U.S. standard.

DOCSIS defines communications and operations support interface standards for cable modems and associated equipment involved in high-speed data distribution over broadband networks.

To qualify for DOCSIS certification, cable modems must meet the requirements defined in the technical specifications. (For detailed specifications, go to www.cablelabs.com.)

DOCSIS 1.0 supports the following specifications:

- Radio Frequency (RF) Interface 1.0
- Operations Support System Interface (OSSI) 1.0
- Baseline Privacy Interface Specification (BPI)
- Cable Modem Termination System (CMTS)—Network
- Cable Modem to CPE Interface (CMCI)
- Acceptance Test Plan 1.0
- Cable Modem Telephony Return Interface

DOCSIS 1.1 supports the following specifications:

- DOCSIS 1.1 RFI Acceptance Test Plan
- Radio Frequency (RF) Interface 1.1
- Operations Support System Interface (OSSI) 1.1
- Baseline Privacy Plus Interface (BPI+)
- Cable Modem Termination System (CMTS)—Network

- Cable Modem to CPE (CMCI)
- DOCSIS 1.1 CMCI Acceptance Test Plan

DOCSIS 2.0 supports the following specifications:

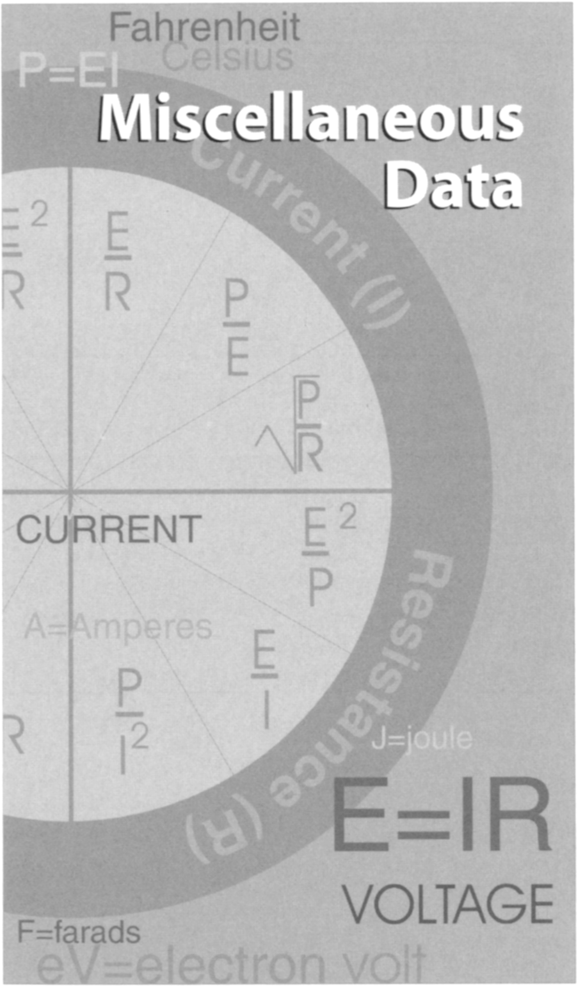
- DOCSIS 2.0 RFI Acceptance Test Plan
- Radio Frequency (RF) Interface 2.0
- Operations System Support Interface (OSSI) 2.0
- Baseline Privacy Plus Interface (BPI+)
- Cable Modem Termination System (CMTS)—Network Side Interface
- Cable Modem to CPE (CMCI)
- Operations System Support Acceptance Test Plan
- Conformance Checklist/PICS Proforma

9.5 Common Industry Data Rates

Industry	Standard/Format	Data Rate (Mbps)
Video	Theoretical limit of 35mm film	144000.000
Telecom	OC-192/STM-64	9953.280
Video	Typical pre-press workstation	2526.000
Telecom	OC-48/STM-16	2488.320
Video	Perceived quality of 35mm film	2400.000
Telecom	HS2	1600.000
Video	Typical pre-press PC	1520.000
Video	Full bandwidth HDTV	1500.000
Telecom	OC-24	1244.000
Video	Compressed HDTV	995.000
Video	Typical engineering workstation	843.000
Telecom	HS1	800.000
Telecom	ATM/OC-12/STM-4	622.080
Video	High-end home PC	506.000
Datacom	"FireWire" (IEEE 1394)	400.000
Video	Mid-range home PC (SVGA)	310.000
Video	DVB-ASI	270.000
Video	CCIR601, including audio, etc.	270.000
Video	PAL 768 x 576	265.400
Video	Component NTSC, studio quality	251.000
Video	NTSC 640 x 480	220.900
Video	Low-end home PC (VGA)	198.000

Industry	Standard/Format	Data Rate (Mbps)
Video	PAL video portion of CCIR601	177.000
Telecom	ATM/OC-3/STM-1	155.520
Video	SMPTE D-2/D-3	143.000
Video	NTSC, video portion of CCIR601	143.000
Telecom	E-4	140.000
Telecom	FDDI	100.000
Datacom	100-Base T Ethernet	100.000
Telecom	OC-1	52.000
Video	BetaSP, MII	45.000
Video	Component NTSC, prod. quality	45.000
Telecom	DS-3/T-3	44.736
Telecom	E-3	34.000
Video	Composite NTSC, prod. quality	23.000
Video	Highly compressed HDTV	20.000
Video	ATSC	19.390
Audio	NV2000	18.400
Video	SVHS/Hi8 NTSC	12.000
Datacom	10Base-T Ethernet	10.00
Telecom	E-2	8.450
Video	MPEG-2 (8-45Mbps)	8.000
Telecom	DS-2/T-2	6.300
Datacom	4x speed CD-ROM	4.600
Video	DBS (compressed)	4.600
Video	Mildly compressed NTSC	4.000
Audio	AES	3.070
Video	U-Matic NTSC tape playback	3.000
Datacom	2x speed CD-ROM, CD video	2.300
Telecom	E-1	2.048
Video	VHS NTSC tape playback	1.544
Telecom	DS-1/T-1	1.544
Video	MPEG-1 384 x 240	1.500
Audio	CD Audio	1.411
Datacom	CD-ROM	1.150
Datacom	Machine control	1.000
Video	Video-conferencing	0.768
Telecom	ISDN	0.144
Datacom	RS-232/RS-422	0.115
Telecom	DS-0/E-0/T-0	0.064
Telecom	Group III fax	0.014
Telecom	Group II fax	0.010
Audio	Telephone Audio	0.008
Datacom	SMPTE/EBU timecode	0.002

Miscellaneous Data


Fahrenheit
Celsius
P=EI
Current (I)
$\frac{E^2}{R}$
$\frac{E}{R}$
$\frac{P}{E}$
$\sqrt{\frac{P}{R}}$
CURRENT
$\frac{E^2}{P}$
Resistance (R)
A=Amperes
$\frac{E}{I}$
$\frac{P}{I^2}$
R
J=joule
E=IR
VOLTAGE
F=farads
eV=electron volt

10.1 Scientific Prefix Symbols and Values

Prefix	Symbol	Value	Power of 10
pico*	p	.000 000 000 001	x 10^{-12}
nano	n	.000 000 001	x 10^{-9}
micro	µ	.000 001	x 10^{-6}
milli	m	.001	x 10^{-3}
-	-	1.	x 10^{0}
kilo	k	1 000.	x 10^{+3}
mega	M	1 000 000.	x 10^{+6}
giga	G	1 000 000 000.	x 10^{+9}
tera	T	1 000 000 000 000.	x 10^{+12}

* µµ is sometimes used in place of ρ for capacitor specifications

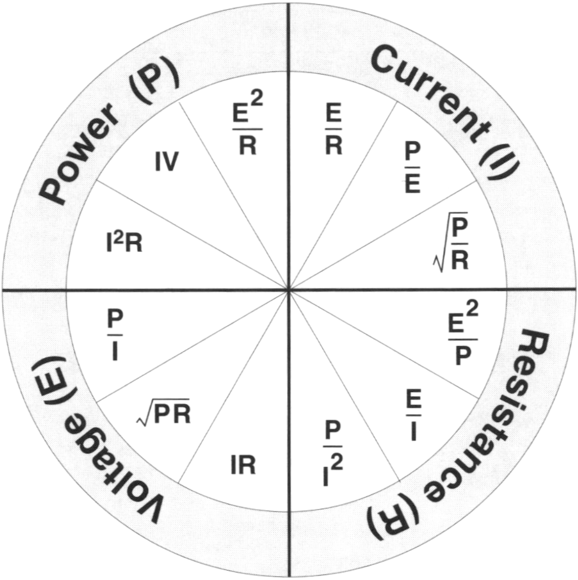
10.2 Unit Abbreviations

A = Amperes
C = Coulomb
cm = centimeter
deg = degrees
eV = electron volt
F = farads
ft = feet
gal = gallons
hp = horsepower
hr = hour
in = inch
J = joule
kg = kilogram
l = liter
Ω = ohm
lb = pound
m = meter
N = Newtons
rad = radians
s = second
V = Volts
VAC = AC Volts
W = watts
yd = yard

10.3 Unit Conversion Factors

To Convert	Into	Multiply By
ampere-hours	coulombs	3600.0 C/A-hr
centimeters	feet	3.281×10^{-2} ft/cm
centimeters	inches	0.394 in/cm
coulombs	farads	1.036×10^{-5} F/C
degrees	radians	1.745×10^{-2} rad/deg
dynes	joules/meter(N)	1×10^{-5} J/m·dynes
electron volts	joules	1.60×10^{-19} J/eV
farads/sec	amperes	96,500 A·s/F
feet	meters	0.3048 m/ft
feet	miles (statute)	1.894×10^{-4} miles/ft
foot-pound	Newton·meter	1.356 ft-lbs/N·m
gallons	liters	3.785 l/gal
inch-pound	Newton·meter	0.113 in-lbs/N·m
joules	electron volts	6.25×10^{18} eV/J
kilogram force·meter	Newton·meter	9.807 kg·m/N·m
kilograms	pounds	2.205 lbs/kg
liters	gallons	0.2642 gal/l
meters	feet	3.281 ft/m
meters	miles (statute)	6.214×10^{-4} miles/m
Newton·meter	foot-pound	0.7376 N·m/ft-lbs
Newton·meter	inch-pound	8.651 N·m/in-lbs
Newton·meter	kilogram force·meter	0.102 N·m/kg·m
newtons	dynes	1×10^{5} dynes/N
newtons	pounds	0.225 lb/n
pounds	kilograms	0.4536 kg/lbs
radians	degrees	57.30 deg/rad
yards	meters	0.9144 m/yd

10.4 Ohm's Law / Joule's Law Pie Chart


Power (P)
Current (I)
Resistance (R)
Voltage (E)
$\frac{E^2}{R}$
IV
I^2R
$\frac{E}{R}$
$\frac{P}{E}$
$\sqrt{\frac{P}{R}}$
$\frac{E^2}{P}$
$\frac{E}{I}$
$\frac{P}{I^2}$
IR
$\sqrt{PR}$
$\frac{P}{I}$

I = Current (Amps)

E = Voltage (Volts)

R = Resistance (Ohms)

P = Power (Watts)

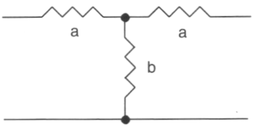
Ohm's Law	**Joule's Law**
E = I R	P = E I

***Note**: In electrical engineering, voltage is sometimes indicated by an E. Also, the standard convention is to indicate time-invariant or fixed current and voltage quantities with uppercase letters (**I, E**) and time-dependent current and voltage quantities with lowercase letters (**i,e**).*

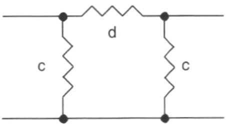
10.5 75 Ohm T and Pi Attenuators

Resistor values for 75 Ohm T- and Pi-attenuators with loss from 0.5 to 20dB are given in the following table.

Loss (dB)	Resistor Value (Ω)			
	T-Attenuator		Pi-Attenuator	
	a	b	c	d
0.5	2.16	1302.16	2606.49	4.32
1.0	4.31	650.00	1304.32	8.65
1.5	6.46	432.14	870.75	13.02
2.0	8.60	322.86	654.32	17.42
2.5	10.72	257.01	524.75	21.89
3.0	12.82	212.89	438.60	26.42
4.0	16.97	157.24	331.46	35.77
5.0	21.01	123.36	267.73	45.60
6.0	24.92	100.40	225.71	56.03
7.0	28.69	83.70	196.09	67.20
8.0	32.29	70.96	174.21	79.27
9.0	35.72	60.89	157.49	92.38
10.0	38.96	52.70	144.37	106.73
11.0	42.02	45.92	133.87	122.49
12.0	44.89	40.22	125.32	139.87
13.0	47.56	35.35	118.27	159.11
14.0	50.05	31.17	112.39	180.46
15.0	52.35	27.55	107.44	204.21
16.0	54.48	24.39	103.25	230.67
17.0	56.43	21.62	99.67	260.18
18.0	58.23	19.19	96.60	293.15
19.0	59.87	17.04	93.96	330.01
20.0	61.36	15.15	91.67	371.25



T-Attenuator



Pi-Attenuator

Construct the attenuator as shown in the appropriate diagram above, using the resistor values from the table column headed by the letter corresponding to the resistor.

Resistor values may also be determined, for attenuators with 75 ohm or any impedance, from the following equations.

$$a = z\left\{\frac{10^{\frac{n}{20}} - 1}{10^{\frac{n}{20}} + 1}\right\} \qquad b = 2z\left\{\frac{10^{\frac{n}{20}}}{10^{\frac{n}{10}} - 1}\right\}$$

$$c = z\left\{\frac{10^{\frac{n}{20}} + 1}{10^{\frac{n}{20}} - 1}\right\} \qquad d = \frac{z}{2}\left\{\frac{10^{\frac{n}{10}} - 1}{10^{\frac{n}{20}}}\right\}$$

where:

n = Loss in dB

z = Impedance in Ohms

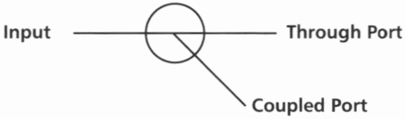
Example: Find the resistor values for a 75 Ω T-attenuator with a 2 dB loss.

$$a = 75\left\{\frac{10^{\frac{2}{20}} - 1}{10^{\frac{2}{20}} + 1}\right\} = 75\left(\frac{1.259 - 1}{1.259 + 1}\right) = 75(0.1146) = 8.60\,\Omega$$

$$b = 2(75)\left\{\frac{10^{\frac{2}{20}}}{10^{\frac{2}{10}} - 1}\right\} = 150\left(\frac{1.259}{1.585 - 1}\right) = 150(2.152) = 322.86\,\Omega$$

10.6 Directional Couplers

Directional couplers are three-port devices that are used in broadband systems to split an RF signal into unequal parts. The through port has minimal insertion loss, and the coupled port (down leg) has the larger insertion loss. The directional coupler has the unique ability to pass signals from the input to the coupled port and reject signals from the through port.



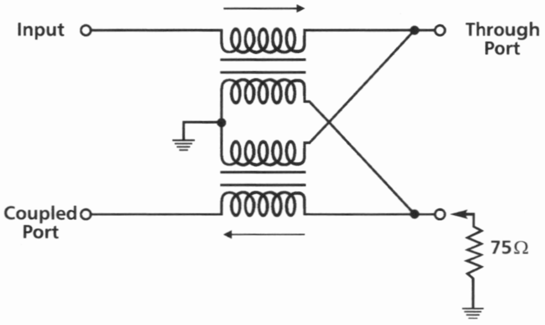
Physically, a directional coupler is a special RF broadband transformer wound on a two-hole ferrite core where the turns ratio determines the coupling value. The coupled value of a directional coupler is represented by the following equation.

$$C_{dB} = 10\log\left(\frac{1}{N^2}\right)$$

Where:

C_{dB} = the coupled value in dB

N = the turns ratio

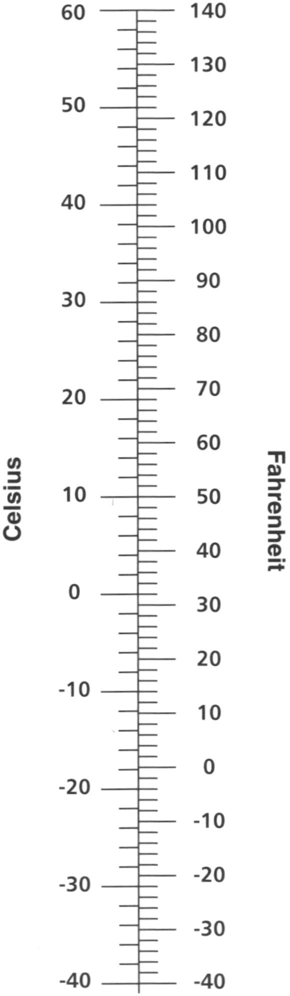


Directional Coupler Schematic

10.7 dBmV to mV Conversion (for 75Ω systems)

dBmV	mV	dBmV	mV	dBmV	mV
-59	0.0011	-19	0.112	21	11.22
-58	0.0013	-18	0.126	22	12.59
-57	0.0014	-17	0.141	23	14.13
-56	0.0016	-16	0.158	24	15.85
-55	0.0018	-15	0.178	25	17.78
-54	0.0020	-14	0.200	26	19.95
-53	0.0022	-13	0.224	27	22.39
-52	0.0025	-12	0.251	28	25.12
-51	0.0028	-11	0.282	29	28.18
-50	0.0032	-10	0.316	30	31.62
-49	0.0035	-9	0.355	31	35.48
-48	0.0040	-8	0.398	32	39.81
-47	0.0045	-7	0.447	33	44.67
-46	0.0050	-6	0.501	34	50.12
-45	0.0056	-5	0.562	35	56.23
-44	0.0063	-4	0.631	36	63.10
-43	0.0071	-3	0.708	37	70.79
-42	0.0079	-2	0.794	38	79.43
-41	0.0089	-1	0.891	39	89.13
-40	0.0100	0	1.000	40	100.00
-39	0.0112	1	1.122	41	112.20
-38	0.0126	2	1.259	42	125.89
-37	0.0141	3	1.413	43	141.25
-36	0.0158	4	1.585	44	158.49
-35	0.0178	5	1.778	45	177.83
-34	0.0200	6	1.995	46	199.53
-33	0.0224	7	2.239	47	223.87
-32	0.0251	8	2.512	48	251.19
-31	0.0282	9	2.818	49	281.84
-30	0.0316	10	3.162	50	316.23
-29	0.0355	11	3.548	51	354.81
-28	0.0398	12	3.981	52	398.11
-27	0.0447	13	4.467	53	446.68
-26	0.0501	14	5.012	54	501.19
-25	0.0562	15	5.623	55	562.34
-24	0.0631	16	6.310	56	630.96
-23	0.0708	17	7.079	57	707.95
-22	0.0794	18	7.943	58	794.33
-21	0.0891	19	8.913	59	891.25
-20	0.1000	20	10.00	60	1000.00

10.8 Celsius/Fahrenheit Conversion



Conversion Formulas

To Celsius

$$°C = \frac{5}{9}(°F - 32)$$

To Fahrenheit

$$°F = \frac{9}{5}(°C) + 32$$

Conversion Shortcut

To °C: Subtract 32; divide by 2; add 10%.

Ex: 56°F to Celsius

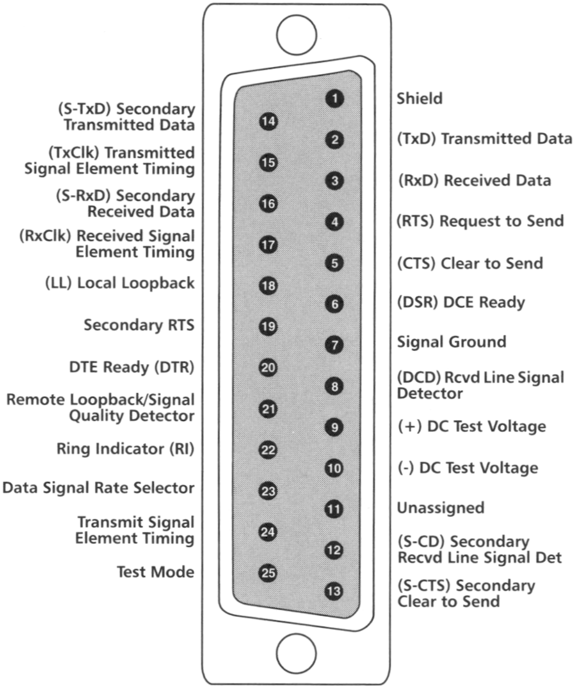
56 - 32 = 24
24/2 = 12
plus 10% ≅ 13°C

To °F: Multiply by 2; subtract 10%; add 32.

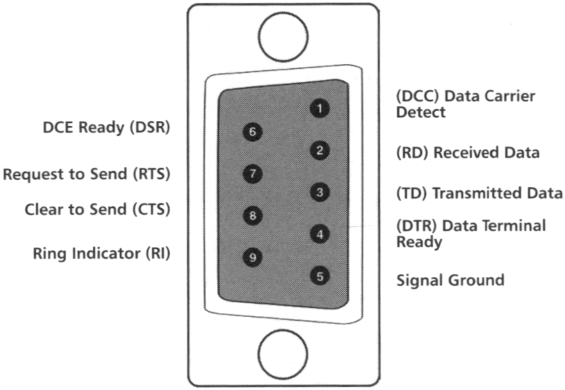
Ex: 8°C to Fahrenheit

8 x 2 = 16
less 10% ≅ 14
14 + 32 = 46°F

10.9 Data Interface Connectors


1 Shield
2 (TxD) Transmitted Data
3 (RxD) Received Data
4 (RTS) Request to Send
5 (CTS) Clear to Send
6 (DSR) DCE Ready
7 Signal Ground
8 (DCD) Rcvd Line Signal Detector
9 (+) DC Test Voltage
10 (-) DC Test Voltage
11 Unassigned
12 (S-CD) Secondary Recvd Line Signal Det
13 (S-CTS) Secondary Clear to Send
14 (S-TxD) Secondary Transmitted Data
15 (TxClk) Transmitted Signal Element Timing
16 (S-RxD) Secondary Received Data
17 (RxClk) Received Signal Element Timing
18 (LL) Local Loopback
19 Secondary RTS
20 DTE Ready (DTR)
21 Remote Loopback/Signal Quality Detector
22 Ring Indicator (RI)
23 Data Signal Rate Selector
24 Transmit Signal Element Timing
25 Test Mode

EIA-232 DB25 Female Connector


DCE Ready (DSR)
Request to Send (RTS)
Clear to Send (CTS)
Ring Indicator (RI)
1
6
2
7
3
8
4
9
5
(DCC) Data Carrier Detect
(RD) Received Data
(TD) Transmitted Data
(DTR) Data Terminal Ready
Signal Ground

EIA-232 DB9 Female Connector

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